MONTANA GREENHOUSE GAS PROJECT:

Building a Foundation for an Action Plan

(December 1999)

DRAFT

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EXECUTIVE SUMMARY

"Greenhouse gases" influence the climate by slowing the loss of heat back into space. Most scientists now believe that human activities emit enough greenhouse gases to noticeably alter the climate. Carbon dioxide from fossil fuel use is the primary, but not the only, greenhouse gas added by humans. The current scientific recognition that climate change is a serious possibility is not matched by a public or political acceptance of the need for comprehensive action, or even necessarily by an understanding of what the options are.

The Montana Department of Environmental Quality (DEQ) undertook this project to provide the information that individuals, businesses and government will need before acting to reduce greenhouse gas emissions. For the most part, the project report analyzes issues that many Montanans already are concerned about for reasons separate from that of reducing greenhouse gases. For instance, helping homeowners reduce their energy bills or changing government regulations that favor urban sprawl, both of which can lead to lower greenhouse gas emissions, already have some support.

It is likely that Montanans will be doing something in the coming years to reduce greenhouse gas emissions. The much publicized doubts about climate science and Congressional opposition to international treaties on greenhouse gases should not obscure the fact that businesses at home and abroad, as well as other governments, already are moving to address global climate change. Montana should be prepared to respond to national and international initiatives. Twenty-four other states have completed or are working on their own greenhouse gas action plans. By having this report, Montana will be better equipped to evaluate and influence proposals on climate change.

The *Montana Greenhouse Gas Project* is only a first step. Montana will not have an official plan without informed public debate. Now, most members of the public and most policy makers have only a vague notion of what preventing climate change might mean to them and what actions they should take. The project report presents detailed analyses of specific issues, which should focus the public debate. With that focus, Montanans should be better able to choose what they must do to reduce greenhouse gas emissions. Realistically, taking actions based on the analyses presented here would reduce, not eliminate, the threat of climate change. But debate over alternatives must start somewhere, or else there never will be legislative action, business plans, or widespread personal commitments to reduce greenhouse gas emissions.

The evidence for human-induced climate change is accumulating but is complicated and largely statistical in nature. The most widely reported evidence comes from computerized models, which, while still evolving, are increasingly accurate. The improvement during the last decade of models forecasting El Niño/La Niña events, simpler but still complex climatic events, indicates the progress being made. Closer to home, research done at the University of Montana indicates spring is arriving earlier in northern latitudes, which could seriously affect forests and other natural ecosystems. Non-statistical, easily visible evidence, such as the receding of glaciers in Glacier Park, clearly shows that climate change of some kind is occurring; more sophisticated analyses suggest greenhouse gases from human activities may be the cause.

In spite of uncertainties, a scientific consensus is emerging. Scientists agree that the atmospheric concentrations of greenhouse gases such as carbon dioxide, methane, nitrous oxide and perfluorocarbons are increasing. The concentration of carbon dioxide alone has increased 30 percent since 1850. There is general agreement that the global climate appears to be changing. Most scientists accept a link between the two changes. In 1995, the Intergovernmental Panel on Climate Change (IPCC), a group of scientists from around the world, stated, "For the first time the balance of evidence suggests there is a discernible human influence on the earth's climate, or to put it another way, the changing climate over the last 100 years cannot be explained by natural variability alone." Research since then has done more to strengthen this conclusion than to weaken it.

Many people and businesses, as well as certain foreign governments, remain unpersuaded. Their concerns could be dismissed as similar to the now-discredited objections raised against early suggestions that the ozone layer was being destroyed. However, a more positive reply to climate change skeptics is that given in May 1997, by John Browne, the chief executive officer of British Petroleum (now BP Amoco):

> The time to consider the policy dimensions of climate change is not when the link between greenhouse gases and climate change is conclusively proven, but when the possibility cannot be discounted and is taken seriously by the society of which we are part. We in BP have reached that point.

The science is increasingly persuasive. The likelihood of a national initiative is growing. Montanans should be concerned with practical questions about the economic and social consequences of programs chosen to reduce greenhouse gas emissions. Montanans ought to be prepared to participate constructively in the national debate.

Reducing greenhouse gas emissions is both simple and complex. It's simple in that what must be done is easily summarized:

- use fossil fuel more efficiently,
- use alternatives to fossil fuel, and
- generate fewer waste products in industrial and agricultural processes.

However, the on-going efforts by individuals, businesses and governments to accomplish these ends, albeit for reasons other than controlling greenhouse gas emissions, shows just how complex the task will be. The answers may require rethinking and replacing existing methods and technology. We must find the ways and the will to do more than we have done in the past. Yet, the sheer magnitude of the idea of climate change, and the seriousness of the possible consequences can cause people and politicians to shy away from direct actions.

Emissions in Montana, as in other states, can be divided into those associated with industrial processes (such as aluminum production, oil refining, electricity generation) and those associated with more dispersed uses (such as residential heating, commercial lighting, driving cars). DEQ already has prepared an inventory of greenhouse gas emissions in Montana. While, as one might expect, the big industrial facilities are major emitters, other smaller sources have significant cumulative emissions. For instance, the transportation sector accounts for one-fifth of all inventoried emissions in Montana. Even our everyday activities are major emitters. Common activities, such as heating houses, lighting commercial buildings, and driving back and forth in town, collectively account for 15-20 percent of emissions.

Greenhouse gas emissions are intertwined with almost every aspect of society. Actions that reduce greenhouse gas emissions also generally reduce emissions of pollutants that are dangerous to health. The U.S. Environmental Protection Agency (EPA) estimates that 85 percent of greenhouse gas emissions nationally come from sources that already are directly regulated under the Clean Air Act. DEQ hopes to encourage practices that speak both to immediate environmental problems and to long-term climate change.

The report covers a wide range of areas. DEQ believes that action in any of these areas would have benefits that extend beyond greenhouse gas issues. DEQ concentrated on market-based alternatives, ones that don't prohibit greenhouse gas emissions, but which do make behavior that reduces greenhouse gas emissions more economically attractive. Some of the more significant areas covered include:

- Highway expenses currently paid through property taxes could be shifted to fuel taxes to give drivers a better idea of the true cost of driving. The change would mean no net increase in taxes, but would reduce the driving that drivers themselves think has the least value.
- The state could search for alternatives to those government requirements that hinder the development of compact, mixed-use and pedestrian friendly urban areas. State and local road design standards, model zoning codes and septic tank requirements are just some examples of regulations and practices that presently can encourage driving and discourage alternatives.
- The restructuring of the electric utility industry could be extended by including the way transmission line use is priced and by decontrolling customer metering and billing. These changes will make the actual cost of electricity more visible, and therefore show how energy efficiency investments are more attractive.
- A carbon tax would make less carbon-intensive activities more attractive and could be used to reduce the net tax burden on most Montanans. However, it is a complicated and contentious issue that would require study before adoption could be considered.

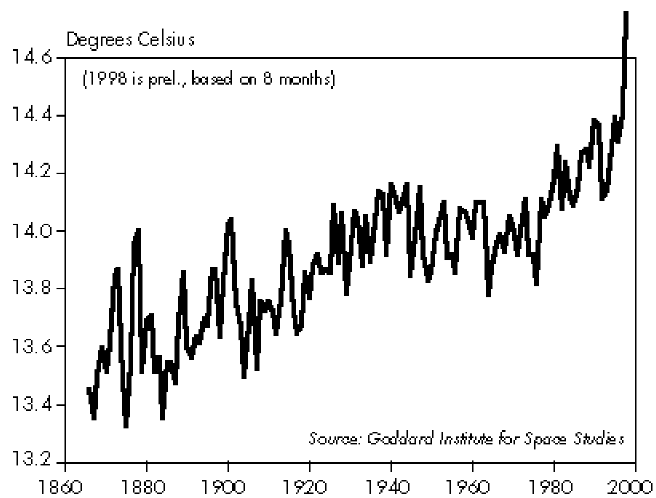
The project report discusses numerous other issues related to greenhouse gas emissions. It also discusses ideas that have been suggested at the national level, but which are not appropriate in Montana. The project report *does not* call for a net increase in taxes. It does show that raising some taxes while lowering others would reduce subsidies—and thereby reduce interest in—activities that emit greenhouse gases and other pollutants. Those losing their subsides may question raising the issue while those seeing their taxes lowered may support the discussion. Overall, reducing subsidies could improve the efficiency of the Montana economy while improving the environment.

The project report does not set a specific legislative agenda. DEQ believes more discussion is necessary before such an agenda can be set. Many of the possible actions may eventually be taken because they make sense in their own right, and not for reasons having to do with climate change. At this point, the only action unique to climate change that DEQ proposes to take is to help protect Montanans who voluntarily act to reduce greenhouse gas emissions. This action could take the form of implementing a state registry of voluntary actions, as New Hampshire already has done (see p.1), to ensure those actions will be recognized whenever national requirements for reductions are established. Beyond that, DEQ will encourage Montanans to develop an understanding and a consensus on actions to reduce greenhouse gas emissions.

The project report is to be used as a background and reference document. Certain sections, especially those dealing with the greenhouse gas science and policy, have extensive footnotes and Internet links. They are designed to aid those seeking more detailed information on a particular topic. These references also show the significant and systematic efforts that have been made on the science of climate change. While disagreements remain, both on the science and on the proper response, there is an extensive body of literature and thoughtful analysis of the problem.

Links are indicated in the text by an underline. Appendix 1 contains a list of all the links, for those who are reading a hard copy of the report. Unless otherwise noted, all links are to sites that are not part of DEQ; DEQ has no control over their content or availability. Some sites cannot be reached through Word with some browsers. If you have problems, copy the link into your browser and try it directly. All the links were operational as of November 1, 1999.

CHAPTER 1: BACKGROUND AND CONTEXT



Average Temperature at the Earth's Surface, 1866–1998

1.1 Introduction

Greenhouse gas emissions are not at the top of the current political or social agenda in Montana. Still, there are arguments for why we should address this issue.

This report presents the arguments for action and discusses areas where Montanans could act to reduce greenhouse gas emissions. Most of the actions likely to grow out of this report would be ones many Montanans will find attractive in their own right. The report is not a legislative proposal, but it should prompt the discussions necessary for acceptable legislative proposals and other initiatives to be developed. Similar discussions have taken place in the twenty four other states that have completed, or nearly completed, their own greenhouse gas action plans.

Climate change is a complex subject. The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases. These are gases that slow the radiation of heat back into space. Carbon dioxide, primarily from the use of coal and oil, is the main greenhouse gas; methane and nitrous oxide also are important. In Montana, perfluorocarbons from aluminum production are significant. The heat-trapping property of greenhouse gases is undisputed. Although uncertainty exists about exactly how earth's climate responds to these gases, global temperatures are rising. Before we can discuss what, if anything, to do about it, some background on the theory and data on climate change is necessary.

1.2 Primer on greenhouse gas science[1]

Energy from the sun drives the earth's weather and climate, and heats the earth's surface; in turn, the earth radiates energy back into space. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy, retaining heat somewhat like the glass panels of a greenhouse. Without this natural "greenhouse effect," temperatures would be much lower than they are now, and life as we know it today would not be possible. Instead, greenhouse gases cause the earth's temperature to average a more hospitable 60° F.

However, problems may arise when the atmospheric concentration of greenhouse gases increases. Since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide have increased nearly 30 percent, methane concentrations have more than doubled, and nitrous oxide concentrations have risen by about 15 percent. According to a recent study, carbon dioxide and methane levels are higher now than at any time in the past 420,000 years.[2] These increases have enhanced the heat-trapping capability of the earth's atmosphere. Proportionately, the amount of greenhouse gases in the atmosphere that are there due to human activities is small. However, that amount could be the critical difference that tips the climate into a different mode.

Scientists generally believe that the combustion of fossil fuels and other human activities are the primary reason for the increased concentration of carbon dioxide. Plant respiration and the decomposition of organic matter release more than 10 times the carbon dioxide released by human activities; but these releases have been in balance with the carbon dioxide absorbed by plant photosynthesis. What has changed in the last few hundred years is the additional release of carbon dioxide by human activities.[3] Energy burned to run cars and trucks, heat and light homes and businesses, and power factories is responsible for almost all of U.S. carbon dioxide emissions, about 34 percent of methane emissions, and about 26 percent of nitrous oxide

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[1] Much of this information is adapted from the EPA webpage as of May 1999.

[2] The study found carbon dioxide levels rose from about 180 parts per million (ppm) during the height of each ice age to 280-300 ppm in the subsequent warm periods—far below the current CO_2 levels. J.R. Petit, et al. "Climate and Atmospheric History of the Past 420,000 Years from the Vostok Ice Core, Antarctica". *Nature* 399, 429 - 436 (1999)

[3] Some of the climate change in the past two centuries is due to an increase in energy from the sun; however, in recent decades greenhouse gases released by human activities appear to be driving climate change. Tom M. L. Wigley, National Center For Atmospheric Research. The Science of Climate Change: Global and U.S. Perspectives. Pew Center on Global Climate Change. June 29, 1999. p.9. This document summarizes the current state of climate science. The same point on the role of changes in solar output is made by Simon F.B.Tett et al.in "Causes of twentieth-century temperature change near the Earth's surface." *Nature*, vol. 399, 10 June 1999, pp. 569-572.

emissions.[4] Increased agriculture, deforestation, landfills, industrial production, and mining also contribute a significant share of emissions. In 1994, the United States emitted about one-fifth of total global greenhouse gases emitted that year.

Estimating future emissions is difficult, because they will be affected by demographic, economic, technological, policy and institutional developments. Several emissions scenarios have been developed based on differing projections of these underlying factors. For example, by 2100, in the absence of emissions control policies, carbon dioxide concentrations are projected to be 30-150 percent higher than today's levels.

Increasing concentrations of greenhouse gases are likely to accelerate the rate of climate change. Scientists expect that the average global surface temperature could rise 1.6 to 6.3° F by 2100, with significant regional variation. The frequency of extremely hot days will increase and the frequency of cold extremes will decrease. Evaporation will increase as the climate warms, which will increase average global precipitation. Soil moisture is likely to decline in many regions, and intense rainstorms are likely to become more frequent. Calculations of climate change for specific areas are much less reliable than global ones, and it is unclear whether regional climate will become even more variable than the global averages suggest.

1.3 Some of the evidence

DEQ staff are not experts on climate change. We, like most other Montanans, must rely on those scientists who study climate. As witnessed by the Intergovernmental Panel on Climate Change report,[5] most of those scientists are convinced that some sort of change is underway and that, in significant part, human activities are the cause. This growing scientific consensus cannot be dismissed easily, especially since alternative explanations have had such difficulty standing up to scrutiny.[6]

As a practical matter, the public's willingness to reduce greenhouse gas emissions depends in part on there being readily observable changes in climate.[7] NASA recognized this need by setting up a Common Sense Climate Index, which allows people to analyze changes in their own region. So far, Alaska is the only part of the United States in which people could readily notice

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[4] Energy Information Administration, U.S. DOE. *Emissions of Greenhouse Gases in the United States 1997*. October 1998.

[5] *IPCC Second Assessment - Climate Change 1995. A Report of the Intergovernmental Panel on Climate Change.* IPCC Secretariat, Geneva, Switzerland.

[6] For instance, satellite data was reported to show that, contrary to the predictions of the climate models, the earth's atmosphere was cooling significantly. Further analysis showed that much of that cooling was actually due to changes in the satellites' orbits, a point conceded by the initial analysts themselves; however, their reanalysis still shows some cooling. Still, as the research is refined, the consensus that some change is occurring continues to strengthen. See *NY Times*. "Scientists Warn Against Ignoring Climate Change" January 29, 1999. p. A16 and "Human Imprint on Climate Change Grows Clearer" June 29, 1999. p. F1.

[7] Other observable changes, such as cooling in the mesosphere, between 30 and 50 miles above earth, might better validate the existence of global warming, but are more difficult for non-scientists to appreciate. (This cooling causes the atmosphere to contract. This phenomenon should not be interpreted to mean the sky is falling.)

that the climate has changed in their lifetimes.[8] Nonetheless, the amount of curious weather patterns around the world is striking. For instance:

- The 10 warmest years in this century all occurred in the last 15 years. On a longer scale, there are indications that the 1990s were the warmest decade of the millennium,[9] with 1998 the warmest year so far.[10]
- Alaska is warming, and much of Canada and Russia along with it. While the average surface temperature of the globe has risen over the last century by 1° F or a little more, scientists at the University of Alaska and elsewhere say that it has increased over the last 30 years by as much as 5° F in Alaska, Siberia and northwestern Canada. The warming has been most pronounced in winter. Permafrost and forests have receded and precipitation patterns have changed.[11]
- In September 1998, the National Weather Service's Climate Prediction Center (CPC) started altering its seasonal forecasts to correct for a shift in climate that has taken some of the sting out of U.S. winters over the past three decades.[12] The CPC uses a combination of computer models and statistics on past weather patterns to develop seasonal forecasts. The CPC recognized that a warming trend had interfered with its work, making it necessary to incorporate slow shifts in climate into its predictions.[13]
- Spring warmth is arriving earlier and autumn coolness is coming later in the Northern Hemisphere. Evidence from a network of 77 research sites across Europe called the International Phenological Gardens shows botanical spring advanced an average of six days, while autumn was delayed an average of about five days.[14] (Montana is at the same latitude as some of these sites.) These findings match those of earlier satellite studies, which found that spring was arriving across the hemisphere about a week earlier in 1991 than in 1981.[15]
- And finally, in another 100 years, Glacier Park may have smaller or no glaciers. This may be part of a local trend unrelated to climate change, given that the glacial retreat began about

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[8] This is consistent with the computer models, which predict climate change will affect the higher latitudes the most.

[9] Michael E. Mann, Raymond S. Bradley and Malcolm K. Hughes. "Northern Hemisphere Temperatures During the Past Millennium: Inferences, Uncertainties, and Limitations." *Geophysical Research Letters*. March 15, 1999.

[10] Michael Mann and Raymond Bradley of University of Massachusetts, along with Malcolm Hughes of the University of Arizona have also found that the warming in the 20th century counters a 1,000-year-long cooling trend. The study appears in the March 15 issue of the American Geophysical Union's *Geophysical Research Letters*.

[11] *NY Times.* "As Alaska Melts, Scientists Consider the Reasons Why" August 18, 1998. p. F1.

[12] Over the last three decades, Montana has been getting slightly warmer, especially during the winter, and slightly wetter during the summer and slightly drier during the winter.

[13] See "When Meteorologists See Red" *ScienceNewsOnline* March 20, 1999.

[14] *NY Times* "Early Signs of Spring and Global Warming" 3-02-99 p. F3.

[15] R.B. Myneni et al. "Increased Plant Growth in the Northern High Latitudes from 1981 to 1991". *Nature*, Vol.386, pp.698-702. April 1997.

1850. However, this trend has a parallel in the recession of ice shelves in Antarctica and glaciers in Greenland.[16]

Finally, it's worth noting that a surprising amount of the research on the evidence and impacts of climate change is being done in Montana. Global climate change research is a worldwide, broad-based effort, in which Montanans are participating fully. The University of Montana is investigating global changes in vegetation that are caused by climate change, especially in forested lands. Montana State University has numerous projects studying plants and animals in Antarctica, an area the climate models predict will be particularly vulnerable to climate change. Glacier National Park is site of a major effort to monitor environmental changes over the long term. So far, DEQ has identified over 30 research projects on climate change based in Montana institutions. Some of the research is being conducted in Montana, other parts involve projects in Antarctica or global monitoring. (See Attachment 2: *Climate Change—Partial List of Research Projects Being Conducted by Montana Scientists, p.1*)

1.4 Effect of climate change

The climate may be changing globally, but the changes are predicted to vary by region. For instance, the southeastern part of the United States actually has been cooling over this century, as has the northeastern portion of the country more recently, even while the average surface temperature of the world overall has been going up.[17] Over the long term, the U.S. is expected to warm faster than the global average. The models suggest there will be more extreme precipitation events, but not every region will see such an increase.

There are no Montana-specific predictions of what climate change will bring to Montana. Most of the models used to study global change don't have sufficient resolution to predict changes within Montana. The closest is a model created by the Department of Energy's Pacific Northwest National Laboratory for the Pacific Northwest, which includes western Montana.[18] This model shows that the region, including western Montana, will have significantly warmer winters in 80 years. Winter snowpack will diminish, creating problems for irrigation and power generation (see chart).

As global warming occurs, other changes are likely. Few people would mind Montana winters being less cold, but they will be concerned about the loss of trout habitat due to summer warming.[19] Increased CO_2 will fertilize forests, at least until other limits, such as water

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[16] W. Krabill, et al. "Rapid Thinning of Parts of the Southern Greenland Ice Sheet" *Science*, March 5, 1999, pp. 1522-1524

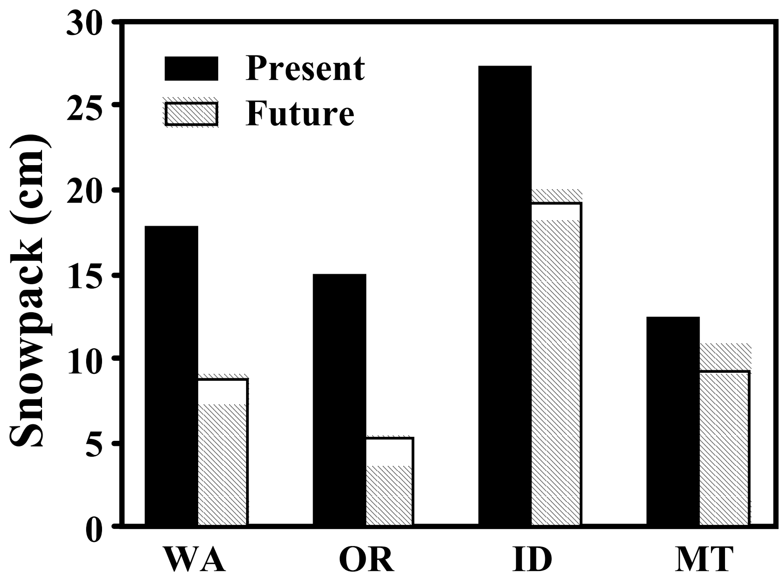
[17] This cooling may be due to the cooling effect of sulfates in the air. This effect of sulfates is very short lived. The amount of sulfates emitted will gradually decline because of efforts to protect human health from their effect.

[18] The results were summarized in a presentation by the University of Washington and PNNL to the Washington State Senate on March 26, 1999

[19] A study in Wyoming found that if average July air temperatures rose by 1.8 degrees, the number of miles of streams supporting trout would shrink by 7.5 percent. A 5.4-degree increase would result in a 21 percent loss. C. J. Keleher and F. J. Rahel. "Thermal Limits to Salmonid Distributions in the Rocky Mountain Region and Potential Habitat Loss Due to Global Warming: A Geographic Information System (GIS) Approach" *Transactions of the American Fisheries Society*. Vol. 125, No. 1, January 1996. Pp. 1-13.

availability, are reached, but overall, forest growth and regeneration may well decrease due to increased aridity, fire frequency, and pest invasions that accompany warming temperatures. Corn will grow better, but the ski season may be shorter.

March Snowpack Under Present and



From: Pacific Northwest National Laboratory

Further complicating predictions, both regional and global, is the growing body of evidence that the climate need not change gradually, but that it can flip flop drastically, in unpredictable ways. For instance, there is clear evidence that the Gulf Stream, which warms Europe and influences weather elsewhere in the world as well, has ceased to flow at different times in the past. Increased precipitation caused by global warming could cause the Gulf Stream and other ocean currents to shut down, which would immediately turn Europe much cooler.[20] The potential for rapid and unpredictable changes such as this make it much more difficult to identify the optimal course of action for reducing greenhouse gas emissions. Science may not be able to tell policy makers how much time they have left to take action.

Other losses are possible due to changes in water temperatures; for instance, caddisflies were wiped out in some parts of the Flathead River Basin because of changes in water temperature caused by dams (Hauer, R., and J.A. Stanford. "Ecological responses of hydropsychid caddisflies to stream regulation." *Canadian Journal of Fisheries and Aquatic Sciences*. 39:1235-1242. 1982.)

[20] "Warming's Unpleasant Surprise." *Science*, 10 July 1998, pp156-158. For a more popular article, see William Calvin. "The Great Climate Flip-flop." *The Atlantic Monthly*. January 1998. Pp.47-64.

Computer models suggest the desertification of the Sahara around 4,000 years ago was another instance of abrupt climate-driven change. Martin Clausse, Claudia Kubatzki, Victor Brovkin, and Andrey Ganopolski. "Simulation of an abrupt change in Saharan vegetation in the mid-Holocene." Geophysical Research Letters, Vol. 26, No. 14, Pp. 2037-2040, July 15, 1999.

In the end, however, worrying about dramatic environmental changes may be beside the point. Climate change is more likely to undermine the social environment before it collapses the physical environment. It could be significant events: both Hurricane Mitch, which decimated Honduras in 1998, and the prolonged drought in northern Mexico have increased illegal migration into the United States. What would be the impact on U.S. society if these climatic events happened more frequently or with greater severity? Or it could be smaller incidents that change society: Atlanta was blanketed by pollen in the spring of 1999, dramatically increasing the suffering of people with allergies and even causing pile-ups on the Interstate.[21] The unusual confluence of the germination cycles of several species of trees was blamed on La Niña. What happens to Atlanta's livability if El Niño/La Niña events become more pronounced? And in areas like Montana, semi-arid lands where agriculture already is difficult, a slight shift in the timing of precipitation could have drastic impact on the viability of farms and the urban areas that depend on them.

Shifts in climate have doomed human societies, from the Neolithic cultures in what is now the Sahara Desert, though the ancient civilizations of Mesopotamia, up to the Viking settlements in Greenland and the Pueblo Indians in the southwestern United States. Nonetheless, large-scale environmental changes rarely change human societies in simple stimulus-response fashion. The resilience and flexibility of the culture and of the economy matter. But even if a country has the ability to ride out environmental changes within its borders, it still must contend with the impact of those changes on its neighbors and its trading partners. Environmental changes and national security are issues of growing concern among foreign policy analysts, and even the CIA has added the environmental dimension to its assessments.[22]

1.5 Reasons for action

We may not have the luxury of sidestepping the question of whether to take action, either on the grounds that Montana's emissions are insignificant or because the U.S., over time, is contributing proportionately less to annual global emissions. The assertion that Montana's contributions are insignificant may be beside the point. Montana's total emissions are indeed less than those of most states, but only because our economy is smaller than that of most states. Depending on how one allocates emissions from industrial facilities such as the generating plants at Colstrip and aluminum plant at Columbia Falls, per capita emissions of greenhouse gases are as great or greater in Montana than in other parts of the United States. If climate change is a problem, Montana is no less responsible than other states. Comparisons with other countries are even less flattering. A recent study shows Montana emissions are equivalent to those of the 250 million people living in 49 developing countries (see graphs on p.1).[23]

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[21] "Atlanta Finds Itself Gasping for Air Under Blanket of Pollen" *NY Times*, April 13, 1999. p. A16.

[22] One of the earlier articles on the subject is by Thomas F. Homer-Dixon. "On the Threshold: Environmental Changes as Causes of Acute Conflict" *International Security*, Fall 1991, Vol.16, No. 2, pp76-116. A popular look at this topic is "The Coming Anarchy", by Robert Kaplan, *The Atlantic*, February 1994.

[23] National Environmental Trust. Leadership and Equity: The United States, Developing Countries and Global Warming. Washington, D.C. November 1998.

The contributions of the United States, and the developed world in general, to annual emissions actually is dwindling in relative terms.[24] However, the heat-trapping effect of greenhouse gases is dependent not on the annual flow of those gases to the atmosphere, but on their total stock in the atmosphere. The annual emissions from developing nations will soon surpass those of developed nations (by 2015 according to one study[25]). But, according to the same study, the cumulative contribution of developing countries will not surpass that of developed countries until 2038. More significantly, even by the year 2100, the per capita contribution from the developed countries is projected to be around 10 times that of developing countries.

If climate change is coming, Montanans' contributions matter. That still leaves the problem of how to decide if action is warranted. One strategy would be to wait until unambiguous signs of climate change in Montana present themselves. There are no such indisputable, common sense signs now. Unfortunately, by the time unambiguous changes do show themselves, it will be too late to avoid unacceptable consequences.[26] Because greenhouse gases remain in the atmosphere for so long, the total amount of greenhouse gases would continue to rise even if annual emissions stopped growing. If the world returned emissions levels to those of 1994, the amount of CO_2 in the atmosphere would continue to increase at a near constant rate for at least two centuries. By the end of the 21st century, concentrations would rise from 358 ppmv (parts per million by volume) in 1994, to about 500 ppmv, nearly twice the pre-industrial concentration of 290 ppmv.[27] Waiting for unambiguous signs is not the answer.

A second strategy would be to listen to the scientists. As discussed above, mainstream science generally accepts that the climate is changing and that human activities are responsible in part. Even though disagreements remain over the degree, timing and mechanisms of change, this general acceptance appears to be growing stronger. Nonetheless, there are scientists who disagree with this consensus, which is confusing to those of us who are not scientists. Since no generally accepted explanation of anything is without flaws, these dissenting scientists should not be dismissed out of hand. All of us non-scientists must sort out which scientist to believe and why. The difficulty of separating out the serious from the spurious objections has been compounded by the politicizing of the issue. In apparently much the same manner as with tobacco and health, and CFCs and the hole in the ozone layer, industry groups and affiliated think tanks have been promoting "sound scientific alternatives" that may not follow standard scientific procedures.[28]

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[24] However, the absolute contribution remains substantial. For instance, the U.S. is the world's largest single emitter of CO_2, accounting for about 23 percent of the annual energy-related carbon emissions worldwide.

[25] Duncan Austin, José Goldemberg, and Gwen Parker. "Contributions to Climate Change: Are Conventional Metrics Misleading the Debate?" World Resources Institute, October 1998.

[26] The flip side of this, also unfortunate from a policy-maker's point of view, is that the correct action—whatever that may be—is best taken before the problem of climate change is visible in our everyday lives.

[27] Intergovernmental Panel on Climate Change *Climate Change 1995: The Science of Climate Change/Summary for Policymakers*. pp29-30.

[28] See, for instance, "Industrial Group Plans to Battle Climate Treaty", *NY Times*, 4-26-98, p.1. A more humorous example is a report on the effort by Arthur Robinson, a physical chemist from Cave Junction, Oregon, to circulate a petition debunking IPCC findings on global warming. He reported gaining "thousands of signatures from scientists."

A third strategy is to wait till others take action and then join the crowd to avoid being left behind. That time is approaching. Some unexpected actors are taking positive actions: BP Amoco and Royal Dutch Shell have announced plans to begin monitoring internal greenhouse gas emissions and to invest in renewables, in part in response to the possibility of climate change.[29] The Business Environmental Leadership Council, which includes major companies such as Boeing, Toyota and Enron, issued a statement (May 7, 1998) "that enough is known about the science and environmental impacts of climate change for us to take actions to address its consequences." The insurance industry is recognizing climate change as one of several reasons natural disasters were so severe and widespread in 1998.[30] And even the U.S. Congress, in spite of its well known opposition to proposed international efforts like the Kyoto treaty[31] on climate change, has started to debate bills calling for actions to reduce greenhouse gas emissions. Given this activity nationally and internationally, Montanans should at least begin thinking about the costs and benefits of different greenhouse gas reduction strategies, to avoid being caught unawares by the activities of others.

The fourth and final strategy is to take action now in those areas where controlling greenhouse gas emissions has other benefits that we already know we want. This is known as a "no regrets strategy," a strategy that guarantees real benefits even if global climate change turns out not to be a major problem. Greenhouse gas emissions are associated with the release of pollutants that already are regulated. Control one and you likely control the other. Controlling these pollutants will have health benefits around the world.[32] And because greenhouse gases, like any pollutant, can be thought of as an indicator of the efficiency of a process, reducing greenhouse gases may be an opportunity to lower costs of an operation.

Most greenhouse gases are emitted by using fossil fuel. Carbon dioxide is the major gas emitted, but nitrous oxide and methane also are released. Burning fossil fuel also is associated with pollutants that are regulated under the federal Clean Air Act ("criteria pollutants"): ozone,

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Among the signatories were Perry Mason and Geraldine Halliwell, previously of the Spice Girls. "Spice Girl Among 'Scientists' On Global Warming Petition." *SF Chronicle*, May 1, 1998, p.A9.

[29] For instance, BP Amoco has set the goal of reducing its greenhouse gases by 10 per cent from a 1990 baseline over the period to 2010. This goal is on a CO2 equivalent basis.

Both these companies are modifying their political stance as well. In 1998, BP Amoco withheld a portion of its dues to the American Petroleum Institute in a dispute over the Institute's lobbying against a global warming treaty, and Shell left the Global Climate Coalition, an industry-supported lobbying organization in Washington, DC.

[30] Comparing the figures for the 1960s and the last ten years, Munich Reinsurance, the largest reinsurance company in the world, reports that the number of great natural catastrophes was three times larger and cost the world's economies—after adjusting for inflation—nine times and the insurance industry fifteen times as much. (December 29, 1998)

[31] The Kyoto Protocol to the United Nations Framework Convention on Climate Change is an international treaty negotiated in December 1997. Once ratified, it would commit signatories to binding goals for reducing greenhouse gas emissions.

[32] See "Short-term improvements in public health from global-climate policies on fossil-fuel combustion: an interim report." *The Lancet* 1997; 350:1341-49. Other information on the study is available from the World Resources Institute.

particulate matter, carbon monoxide, sulfur dioxide, and nitrogen oxides.[33] Many of the strategies to meet the health-based standards for these pollutants also will reduce greenhouse gas emissions. Likewise, reducing fossil fuel use will reduce problems for which regulations are just being developed, such as regional haze and airborne mercury. State and local air pollution officials already have recognized this relationship between greenhouse gases and criteria pollutants in *Reducing Greenhouse Gases and Air Pollution: A Menu of Harmonized Options,* a document that lays out strategies that reduce both.[34]

Reducing air pollution clearly reduces social costs. It would be a mistake to assume that it can't reduce private costs as well. Reducing CO_2 emissions means reducing fuel costs. Reducing fuel use may mean redesigning a process resulting in a cheaper or better product. For instance, residential energy codes spurred introduction of high-efficiency windows, which produced more comfortable houses as well as lower fuel bills. New transformers on utility lines offer higher reliability and lower energy losses.

Reducing emissions primarily means switching to fuels with lower carbon content and increasing energy efficiency. While Montana has no formal policy addressing greenhouse gas or climate change, reducing greenhouse gas emissions would be consistent with the Legislature's policy on energy: "It is the policy of the state of Montana to promote energy conservation, production, and consumption of a reliable and efficient mix of energy sources that represent the least social,

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[33] Carbon monoxide is an air pollutant as well as a contributor to smog. Motor gasoline and diesel use emits more carbon monoxide per unit of energy used than any other fuel in Montana. In cities nationwide, as much as 95 percent of all carbon monoxide emissions may come from automobile exhaust (EPA *1997 Air Quality Trends Report*. December 1998, Ch.2,p.10) Four towns in Montana are working with EPA to reduce CO emissions: Missoula, Billings, Great Falls, and Kalispell.

Particulate emissions consist of soot, smoke, and other suspended matter resulting from the burning of fossil fuels, as well as dust from a variety of sources. PM-10 emissions are of the greatest concern because they can most easily enter humans' lungs. Butte, Columbia Falls, Kalispell, Lame Deer, Libby, Missoula, Polson, Ronan, Thompson Falls and Whitefish are non-attainment areas for PM-10.

Sulfur oxides are health hazards and significant contributors to acid rain. Burning any fossil fuel emits sulfur oxides, but the combustion of coal produces the largest amount per unit of energy used. Sulfur oxides react to form acid precipitation that acidifies waterways and damages plant life. Sulfur oxides can remain in the atmosphere for up to ten days after they are emitted and can be carried more than 600 miles before they are deposited as precipitation. Thus, emissions in one region can cause impacts in distant regions. East Helena and Laurel are sulfur dioxide non-attainment areas.

Nitrogen oxides emissions lead to the formation of ground-level ozone, the major constituent of smog, and contribute to acid precipitation, which acidifies lakes and streams and harms forests.

Volatile organic compounds (VOCs), sometimes referred to as non-methane hydrocarbons, can be toxic, and as a group they contribute to ground-level ozone. Ground-level ozone, the major component of smog, is formed from the combination of VOCs and nitrogen oxides as they react in the presence of heat and sunlight. The primary source of the constituents of ground-level ozone is auto exhaust.

In addition to the human health effects of energy emissions, these pollutants also are responsible for extensive environmental deterioration, damage to agriculture and wildlife, the corrosion and soiling of buildings, the degradation of visibility, and the contamination of water.

[34] State and Territorial Air Pollution Program Administrators (STAPPA) and Association of Local Air Pollution Control Officials (ALAPCO) *Reducing Greenhouse Gases and Air Pollution: A Menu of Harmonized Options*. October 1999.

environmental, and economic costs and the greatest long-term benefits to Montana citizens" (MCA 90-4-1001). Any state action to support energy efficiency[35] and renewable energy reduces greenhouse gas emissions.

In keeping with that general policy, Montana has a number of income and property tax incentives for energy-efficiency and renewable energy investments.[36] Montana has several energy education and technical assistance programs. The main investment program is the State Buildings Energy Conservation Program, through which the state acts as its own energy service company, retrofitting state buildings and paying for the work out of the energy savings. Montana supports a low-income weatherization program. Montana is well on the way to deregulating electric power production and to giving consumers more choice in selecting a power provider. Some of the polices implemented as part of this deregulation could favor energy efficiency and renewable energy. Restructuring includes a universal systems benefit charge (USBC) levied on all sales of electricity within the state at the meter. The USBC will be used to fund energy efficiency and renewable energy investments.

Starting with a no-regrets strategy means Montana could reduce emissions even before it's reached a consensus on the seriousness of global warming. However, pursuing a no regrets strategy does not mean state and local governments have no role to play. They need to direct attention to those no regrets actions and encourage them to be taken. Because energy use, the primary cause of greenhouse gas emissions, is so fundamental to the economy and to the society, and the consensus on global warming still is forming, government actions should emphasize flexibility and innovation. This means focusing on outcomes, not on technologies. This means making sure the prices for different economic activities cover the costs they impose. This means regulations in related areas should be harmonized, to guarantee that fixing one problem isn't creating another. Accordingly, many of the conclusions in this report could lead to state and local government action in tax policy and in provision of information, rather than mandating specific reductions of greenhouse gas emissions.

1.6 Greenhouse gas emissions in Montana

Not all greenhouse gases contribute equally to trapping the Earth's heat. Not all stay in the atmosphere the same length of time. Scientists use an index to compare climatic heating effects of different gases over various time scales. They term this index the "global warming potential" (GWP). The GWP of a gas must be known to assess the impact of taking actions to reduce emissions.

Each greenhouse gas is assigned a numerical rating to indicate its GWP in relation to the GWP of an equal amount of carbon dioxide, the most significant greenhouse gas emitted by human actions. Carbon dioxide, as the basis for the index, has a GWP of 1. The values assigned the other gases can vary somewhat by the expert making the rating and the time scale being used in

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[35] Some people still refer to "energy efficiency" as "energy conservation" but strictly speaking, they are not the same. Energy conservation implies using less fuel. Energy efficiency implies using less fuel per unit of work done.

[36] These tax breaks are listed in the Attachment 3: *Incentives For Alternative Energy And Energy Efficiency*, p.173.

the comparison.[37] The IPCC estimates of GWP over a 100-year time horizon for gases that matter in Montana are:

Carbon dioxide	-	1
Methane (CH_4)	-	21
Nitrous oxide (N_20)	-	310
Perfluoromethane (CF_4)[38]	-	6,500
Perfluoroethane (C_2F_6)[39]	-	9,200

Estimates of emissions from some process or activity often are reported in carbon dioxide equivalents, to incorporate the GWP of different gases and to offer comparative estimates between different gases.

DEQ prepared an inventory of the amount of greenhouse gas emissions in Montana in 1990. We estimated total emissions at the equivalent of 29.8 million tons of CO_2, about 37 tons per person.[40] About 3/4 of those emissions was in the form of CO_2, and was primarily from fossil fuel use. Petroleum combustion accounted for over 1/3 of the emissions. Coal was the next largest, followed by natural gas and by aluminum manufacturing. Emissions came from all types of use, but transportation[41] and industrial use predominated. (See graphs)

[37] The GWPs reported here are those endorsed by the IPCC in 1995. The Montana inventory used the published GWPs available at the time, which were slightly different than the ones IPCC endorsed in 1995. The typical uncertainty for global warming potentials is estimated by the IPCC at "35 percent. Intergovernmental Panel on Climate Change *Climate Change 1995: The Science of Climate Change/Summary for Policymakers*. pp.25-26.

[38] Also known as carbon tetrafluoride.

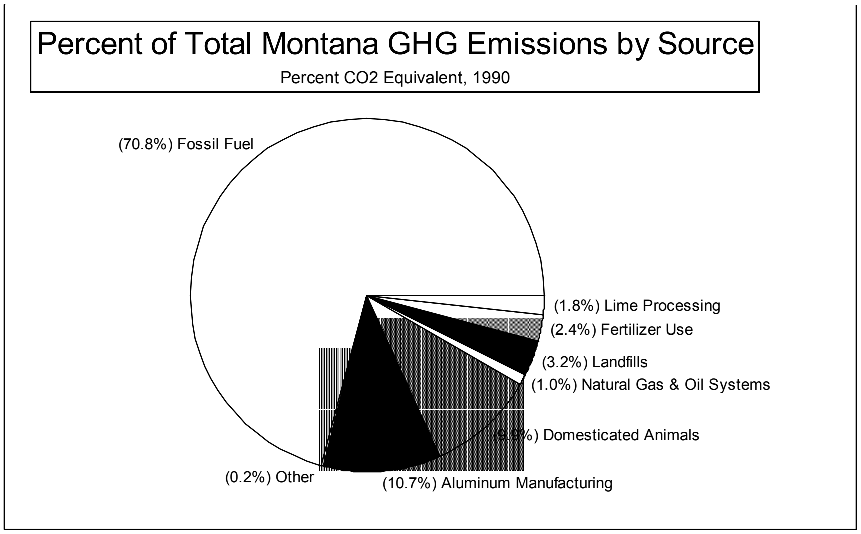
[39] Also known as carbon hexafluoride.

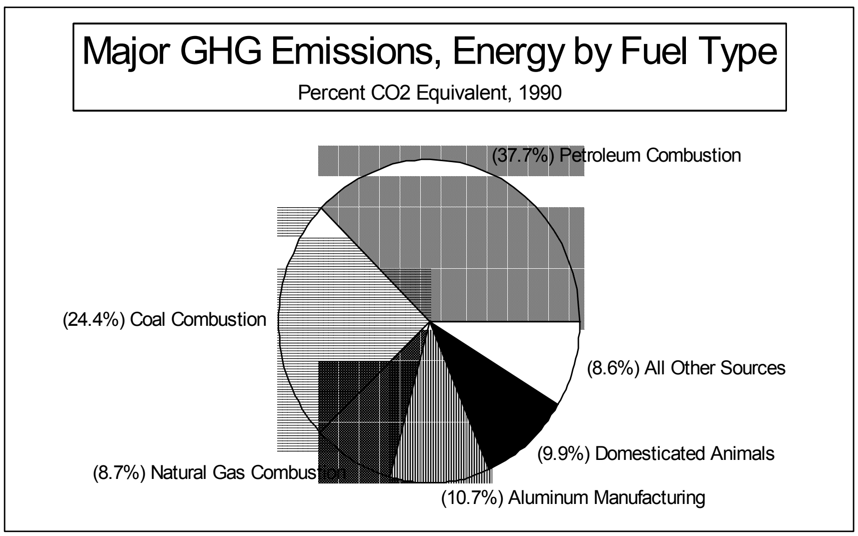
[40] This inventory was prepared as part of a national effort; 34 other states plus Puerto Rico have undertaken a greenhouse gas inventory. Montana's inventory followed EPA's convention on emissions from the production of products used elsewhere. Over half the electricity generated in the state is exported; the 8.9 million tons of CO_2 equivalent emitted in the production of those exports are, for bookkeeping purposes, assigned to the state in which the electricity is consumed. Montana's share of the emissions is apportioned by sector based on the amount of electricity consumed in Montana. The emissions for other products produced here, but consumed elsewhere, such as aluminum, are counted in Montana emissions. Emissions from burning oil, coal and natural gas produced in Montana but used elsewhere are attributed to the state of use.

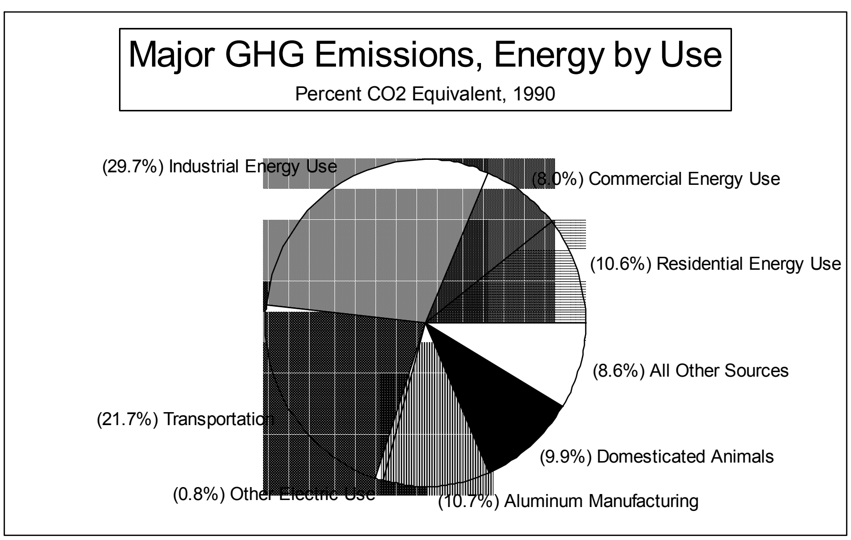
Request copies by e-mail (grnhouse@state.mt.us) or by writing:

Greenhouse Gas Project
Department of Environmental Quality
1520 E. Sixth Ave.
Helena, MT 59620

[41] Transportation emissions don't include emissions from the production or refining of oil to make transportation fuels.


Percent of Total Montana GHG Emissions by Source
Percent CO2 Equivalent, 1990
(70.8%) Fossil Fuel
(1.8%) Lime Processing
(2.4%) Fertilizer Use
(3.2%) Landfills
(1.0%) Natural Gas & Oil Systems
(9.9%) Domesticated Animals
(0.2%) Other
(10.7%) Aluminum Manufacturing


Major GHG Emissions, Energy by Fuel Type
Percent CO2 Equivalent, 1990
(37.7%) Petroleum Combustion
(24.4%) Coal Combustion
(8.6%) All Other Sources
(9.9%) Domesticated Animals
(8.7%) Natural Gas Combustion
(10.7%) Aluminum Manufacturing


Major GHG Emissions, Energy by Use
Percent CO2 Equivalent, 1990
(29.7%) Industrial Energy Use
(8.0%) Commercial Energy Use
(10.6%) Residential Energy Use
(8.6%) All Other Sources
(21.7%) Transportation
(9.9%) Domesticated Animals
(0.8%) Other Electric Use
(10.7%) Aluminum Manufacturing

These emissions are likely to climb if we make no special effort to reduce them. DEQ does not have the forecasting models to make its own estimates, but based on forecasts prepared by U.S. Department of Energy and extrapolation of existing trends, carbon dioxide emissions in Montana are likely to increase by almost half between 1990 and 2010. Emissions of the other greenhouse gases are likely to remain stable or increase slightly. More precise projections will be necessary once Montana has made a commitment to take actions beyond those that clearly are "no regrets."

1.7 Overview of the report

The rest of this report discusses areas in which Montanans might take to reduce greenhouse gas emissions. This report emphasizes areas in which strategies that reduce greenhouse gas emissions already have supporters, even if for reasons other than climate change. Hopefully, the possibility of global climate change will add extra impetus to taking those actions. The report also discusses strategies that, though they have been suggested at the national level, are not appropriate for Montana at this time for one reason or another. Montanans must be aware of such strategies and be able to point out their shortcomings.

Greenhouse gas emissions exist all across our economy and society. Likewise, possibilities for reducing greenhouse gas emissions exist across the board. People reading this report should evaluate it as a package before deciding that they are "for" or "against" taking action. A comprehensive package of actions will have benefits as well as costs for the vast majority of people, even leaving aside the benefit of avoiding unacceptable climate change. It's likely that most people will see more benefits than costs, since actions to reduce greenhouse gas emissions also improve the efficiency of the economy and lessen the effect of other pollutants on public health and the environment

Even the coal and oil industries, those industries most likely to be affected by actions to prevent climate change, may not be affected in any ruinous way. Any realistic plan will be implemented gradually over time. The coal and oil industries are more likely to see a slowing of growth, rather than precipitous decline. This would allow existing capital investments to be recovered and employment to shift in an orderly manner.

In general, readers should neither fear too much nor expect too much from actions based on this report. Those actions could have some immediate impact on consumption, but not monumentally so. They could have some effects on the distribution of wealth in the economy, with some people and some industries ending up better off and some less so. The main effect of any actions would be to signal directions for future capital investment. By changing our patterns of investments now, in ways that get us benefits we already know we want, Montanans will be better prepared to take action once a political consensus on addressing climate change is reached.

Whether we take action now to avoid climate change, or let climate change overwhelm us or our children, our economy and society will change. Our only choice is whether to make those changes thoughtfully and deliberately, or to have those changes thrust upon us.

graphs for Montana

See footnote 23, p1.

CHAPTER 2: TRANSPORTATION COST AND ALTERNATIVES

2.1 Summary of conclusions

The amount of travel (vehicle miles traveled—VMT) has risen and is likely to continue to rise. Unless the efficiency of Montana vehicles increases or VMT decreases, fuel use will continue to grow. What states (and local governments) may be best positioned to do is to influence the amount of VMT. They can do this by improving price signals, so consumers have a better idea of how much it actually costs to drive. They can encourage alternatives such as telecommuting or carpool/vanpool operations. And, they can change the ways communities and their infrastructure are designed, since both of these influence the amount of driving people need to do (discussed in Chapter 3: Transportation and Urban Design, p.1).[42]

The other major strategy, improving the efficiency of vehicles, for the most part is best carried out by the federal government and by those states with markets large enough to attract the

[42] Montana and other states will not be acting on greenhouse gases by themselves. On May 5, 1999, the U.S. Department of Transportation announced that it is organizing a Center for Climate Change and Environmental Forecasting. The center will provide expertise to conduct research and develop solutions, address environmental issues and strategies, and provide a standing analytical support capability for climate-related issues.

attention of the automobile industry. All states, of course, can support these national efforts. They all can act to improve the efficiency with which vehicles are used, such as by what speed limits they set.

Finally, switching to lower carbon fuels would reduce the amount of greenhouse gas emissions. Alternative fuels research and development is best carried out by the federal government or states with the requisite industrial base. There are some niche markets, such as biodiesel, that Montana might be able to develop.

Improving market signals on the cost of driving is the strategy Montana is best positioned to carry out. The market could be used to signal all the costs of driving, including financial, environmental, congestion and so forth. Because any increases in vehicle fuel taxes could be contentious, raising the total cost of driving probably is *not* a practical first step in reducing greenhouse gas emissions. Instead, it would be more reasonable to talk about shifting existing monetary costs of driving to costs that drivers pay at the time of driving, primarily through changing the price of fuel. Current policies obscure the real cost of driving. Shifting existing costs so they are visible at the time people decide to drive will cause people in some instances to shift to other means of travel, to use more efficient vehicles or to forego travel they don't feel is particularly valuable. This shift in costs *would not* increase the total cost of driving, although those who use the roads more will appropriately bear more of their share of the costs. Shifting the costs of driving would add $0.239 per gallon of fuel, while allowing taxes on property to be *reduced* by 8.7 percent across the board and *nearly eliminating* the costs of registration and licensing for the majority of drivers. In a similar manner, the federal government could require petroleum users pay to maintain the Strategic Petroleum Reserve, since they are the ones that benefit. This would add around $0.013 per gallon to the federal gas tax.

There are other policies that Montanans could pursue to reduce transportation emissions:

- Offer public and private employees the option of cash benefits instead of free parking at work ("cash out parking")
- Encourage the federal government to support development of super-efficient cars
- Encourage Congress to allow states to establish fee and rebate programs ("feebates") to encourage purchase of more efficient tires
- Expand rural Transportation Management Associations (TMAs) where appropriate
- Investigate the feasibility of expanding telecommuting options for state workers
- Promote the development of niche markets for bio-fuels

Finally, there are options that have been discussed nationally, but for one reason or another probably are not worth pursuing in Montana at this time. Montana may wish to monitor developments in these areas to see if they become more appropriate for Montana at some time in the future:

- Increase national vehicle efficiency standards ("CAFE" standards)
- Reduce speed limits
- Shift some portion of the cost of major roads to taxes on the benefiting areas
- Establish a feebate program to encourage the purchase of more efficient vehicles
- Institute pay-at-the-pump car insurance

2.2 Background

2.2.1 Driving patterns

The transportation sector is the largest emitter of greenhouse gases in the U.S. and the fastest growing.[43] In Montana, on-road driving accounted for about 92 percent of the gasoline use and about 40 percent of the distillate fuel (diesel fuel) use in 1990. Carbon dioxide (CO_2) from highway use accounted directly for about 18 percent of Montana's inventoried emissions of greenhouse gases.[44] Allocating refinery CO_2 emissions to the final use of gasoline and diesel fuel would increase highway related CO_2 emissions to about 20 percent of all emissions.

Montanans drive a lot, officially 10,697 miles per year per capita in 1997, twelve percent greater than the national average. Montana's wide-open spaces sometimes are cited to explain the high amount of driving; however, the variety of states with greater driving per capita suggests that the real explanation is more complicated. In 1997, 16 states had higher amounts of driving per capita than did Montana.[45] Montana has a population of almost 900,000, but visitation to the state is 10 times that, with most visitors driving here in private vehicles.[46] The large proportion of traffic due to tourists and other non-residents traveling through the state compared to the small state population may explain in part the high per capita driving. Further, the amount of driving in Montana is expanding at a slower rate than in the country as a whole. The number of vehicle miles traveled (VMT) increased 42 percent between 1980 and 1997 in Montana (average of 2.1 percent per year), compared to 67 percent nation-wide (average of 3.1 percent per year).

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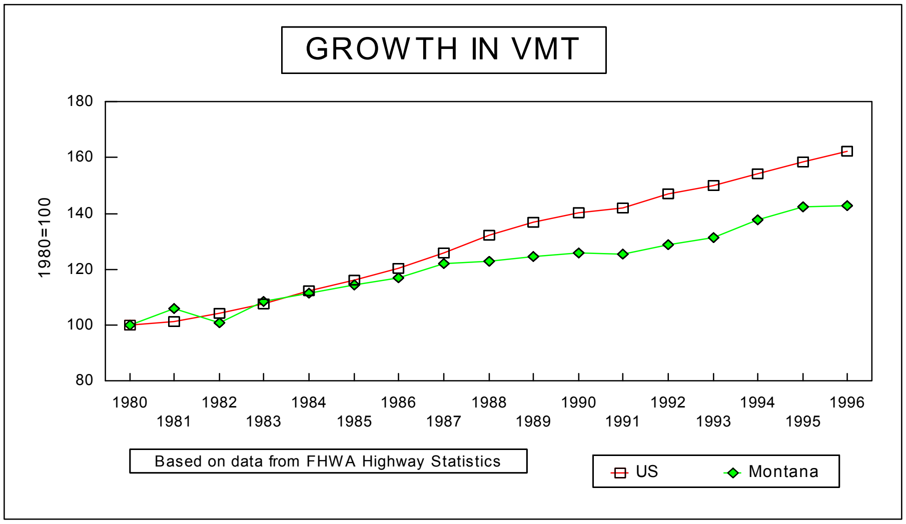
[43] DOE Energy Information Administration. *Annual Energy Outlook* 1999. p.38.

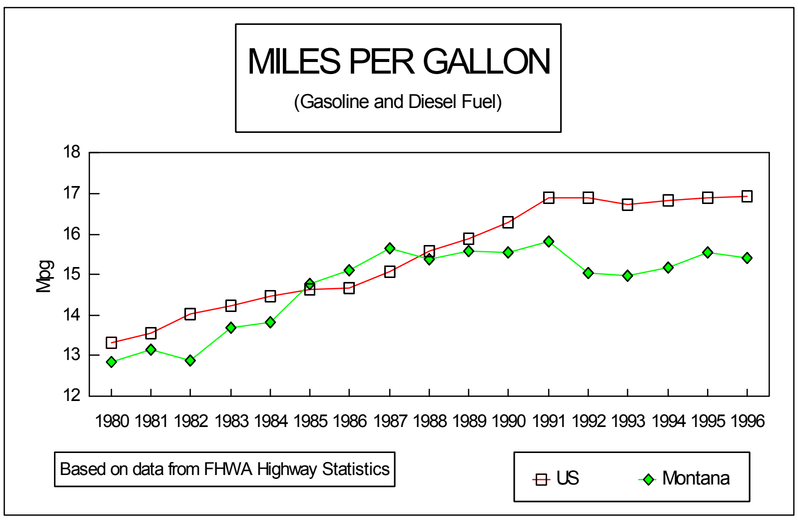
[44] Montana did not inventory nitrous oxide (N_20) emissions from vehicles, due to the lack of an adequate model for state-level emissions. Based on national estimates, N_20 emissions from vehicles in Montana could have been equivalent to about 5 percent of the CO_2 emissions from vehicles.

EPA has not yet provided a model for estimating the amount of hydrofluorocarbons (HFCs) and chlorofluorocarbons (CFCs) emitted from vehicle air conditioners. (HFCs would be controlled under the proposed Kyoto treaty. CFCs are controlled under the Montreal Protocol on ozone-depleting substances.) The impact of HFC and CFC emissions from vehicles may be equivalent to about 1 percent of vehicle CO_2 emissions.

[45] Alabama, Arkansas, Delaware, Georgia, Indiana, Kentucky, Mississippi, Missouri, New Mexico, North Carolina, North Dakota, Oklahoma, South Carolina, Vermont and Wyoming. The ranking of states in terms of driving per capita changes somewhat year to year. (Federal Highway Administration. *Highway Statistics 1997*. Table PS-1.)

[46] Institute for Tourism and Recreation Research. *Montana Vision Travel Research: Special Edition*. University of Montana, Missoula MT. Volume 4, Issue 1, February 1999.





The Montana vehicle fleet uses more fuel per mile traveled than the national average.[47] In 1997, vehicles in Montana obtained 14.9 miles per gallon (mpg) of gasoline and diesel fuel, compared to the national average of 17.0 mpg. In recent years, vehicles in Montana typically have gotten 10 percent fewer miles per gallon of fuel than the national average. Further, the relative efficiency of vehicles in Montana appears to have declined over the last 10 years. This could be due to a number of reasons. The fleet mix,[48] either for vehicles based in Montana, or for vehicles traveling through Montana, may differ enough from the national norm to influence fleet efficiency.[49] The amounts different types of vehicles are driven may be different from national

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[47] As reported in FHWA Highway Statistics, Tables MF-25 and MF-26 (1983-1993), MF-21 (1994-1997), VM-202 (1980-1985) and VM-2 (1986-1997).

[48] Such as size and age of vehicles, or number of trucks in general and large or combination rigs specifically.

[49] For instance, the median age for Montana cars and light trucks appears to be about one year older than the national figure (around 9 years versus around 8 years). Because the national fleet average mpg for new vehicles has

norms, which also could decrease the average fleet economy for Montana as compared to the U.S. average.[50] The length and the degree of cold weather in Montana reduces average engine efficiency; as the U.S. population continues to shift to warmer climates, the efficiency of Montana transportation relative to the nation's could drop. Land use patterns, with the increasing amount of rural sprawl development, could influence average use, though probably not to the extent indicated by the fuel consumption data. Finally, the difference may be more apparent than real, a statistical artifact caused either by the small size of the Montana population (0.3 percent of the U.S. population) or by problems in the data on travel in Montana.

2.2.2 Fuel use: historical and forecast

Between 1980 and 1997, gasoline taxed for highway use in Montana only increased by 12 percent (0.7 percent per year) and diesel use by an apparent 78 percent (3.5 percent per year), for an overall increase in fuel use of 22 percent.[51] This average annual increase of 1.2 percent is slightly over half the annual increase in VMT over the same period, showing that the mix of vehicles driving in Montana has become more efficient on average.

There are no long-term forecasts of vehicle fuel use or travel in Montana. MDT's *TranPlan 21*, released in February 1995, projected VMT on its system (the major roads in Montana) to increase about 2 percent per year through 2010.[52] EPA estimates growth in VMT in Montana on all roads will average 2.2 percent between 1995 and 2010.[53] Both these estimates are only slightly below the historical rate. DOE Energy Information Administration (EIA) projects VMT to grow nationally at the rate of 1.8 percent (average, 1997-2010).[54] EIA projects national gasoline use to grow at 1.7 percent per year to 2010 and diesel fuel use to grow at 2.0 percent per year.[55]

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been dropping since 1990 (see p.40), it is not clear what the overall affect of the older median age is on Montana's fleet mpg.

[50] For instance, large trucks (trucks with more than 4 tires) use far more fuel per mile traveled than do other vehicles. Overall, about 14 percent of the miles traveled on major roads (rural and urban) in Montana in 1997 was done by large trucks, compared for instance to 13 percent in Illinois and 8 percent in California, two of the most populous states. (Most states actually had a higher percentage of large truck traffic on their rural interstates than did Montana. However, unlike in most other states, driving in Montana is predominantly in rural rather than in urban areas. Consequently, a larger portion of the total driving in Montana was done by large trucks than in most states.) Derived from: FHWA *Highway Statistics '97*. Tables VM-2 and VM-4.

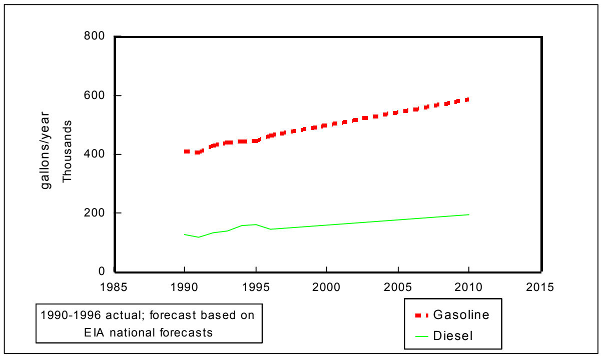
[51] Increase in diesel use is overstated due to under reporting of use prior to 1994. See MDT *Report to the 54th Legislature*.1994. p.8.

[52] Taken from p.15 and from Exhibit 8, p.14, *TranPlan 21*. The rates of growth varied from 3.9 percent in the Missoula-Kalispell area to 1.4 percent in Billings and eastern Montana.

[53] *National Air Pollutant Emission Trends, Procedures Document, 1900-1996*. P.6-31. May, 1998. These estimates were disaggregated from national VMT projection data by vehicle type output by EPA□s MOBILE4.1 Fuel Consumption Model (FCM). These estimates are more reliable for the larger states.

[54] EIA *Annual Energy Outlook 1999*, Table A7. Transportation Sector Key Indicators and Delivered Energy Consumption. Reference case. p.123.

[55] EIA *Annual Energy Outlook 1999*, Table A2. Energy Consumption by Sector and Source. Reference case. P.114.



As a default, DEQ assumes that Montana transportation fuel use will follow the EIA national forecasts. These rates are 0.2 percent below recent observed rates of growth in fuel use in Montana. Since this period has been an economic boom in Montana, it's likely the recent observed rates are above long-term average rates. Under this forecast, gasoline consumption will grow from 411 million gallons in 1990 to 590 million in 2010. Diesel fuel will grow from 125 million gallons to 193 million gallons over the same period.

2.2.3 Related pollution

While transportation fuel use is a major source of greenhouse gases, it also causes emission of pollutants that already are regulated because of their effect on human health.[56] Several towns in Montana have been designated "non-attainment areas" for their failure in the past to meet national air standards.

Particulate matter (PM-10) is the major transportation-related pollutant in Montana. Montana non-attainment areas for PM-10 are Butte, Columbia Falls, Kalispell, Lame Deer, Libby, Missoula, Polson, Ronan, Thompson Falls and Whitefish. Transportation PM-10 comes primarily from road dust, but also from tailpipe emissions and from brake linings. The major strategies for reducing PM-10 have been improved street sweeping and use of liquid deicer instead of sand. If VMT continues to increase, these strategies could become inadequate at some time in the future.

Carbon monoxide (CO) is the other major transportation-related pollutant. CO non-attainment areas are Great Falls, Missoula, and Billings. In addition, Kalispell is required by EPA to implement a program to reduce the amount of CO released. CO is created when fuel is burned in a vehicle's engine. In Missoula, a small amount of ethanol, an oxygenate, is added to gasoline to reduce CO emissions. Rebuilding parts of the road network, especially intersections, has been used to smooth traffic flow and reduce CO from accelerating, decelerating and idling cars.

Sulfur dioxide (SO_2) is a major pollutant in Billings. Most of the SO_2 emitted in Billings in 1997 was from refineries, whose primary products were gasoline and diesel fuel. Changes in the demand for fuel could change the amount of SO_2 in Billings.

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[56] That vehicle accidents are a major cause of injury and death could be added to this discussion of health effects. Programs that reduce air pollution by reducing the amount of miles traveled should reduce the number of accidents as well.

Because the amount of PM-10 released is related to the amount of driving, as is CO to a lesser extent, any reductions in the amount of driving will reduce air pollution as well as greenhouse gas emissions.

In addition to polluting the air of a town, transportation fuel use can pose problems specifically for drivers. A recent study by the California Air Resources Board and the South Coast Air Quality Management District found that exposure to some air pollutants and toxic compounds may be ten times higher inside vehicles than in ambient air.[57]

2.3 Making the price of driving more accurate

2.3.1 Overview

Current transportation policies encourage overuse of driving because they both underprice the real cost of driving and send misleading signals on costs users actually do pay. If drivers, each time they got in their car, had to pay out of pocket all the financial and environmental costs of driving, they would choose to travel less or would substitute less expensive modes for some trips. Because current pricing practices send signals that don't reflect the true resource costs of driving, the individual transportation decisions people make do not sum to the most efficient use of resources for the society.[58] Instead, at least in economic terms, there are too many resources devoted to driving and cleaning up the damage (such as health problems worsened by air pollution) caused by driving, and too few resources devoted to other parts of the economy. As it is, both Montana's economy and the national economy are less efficient than they could be, and people in Montana and the U.S. worse off than they need be, because of our transportation policies.[59]

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[57] Air Resources Board. "Measuring Concentrations Of Selected Air Pollutants Inside California Vehicles." ARB Contract No. 95-339. December 1998.

[58] The costs of driving probably are higher than most people realize, even if one looks only at costs to the driver. A report by Jack Faucett Associates, *Cost of Owning & Operating Automobiles, Vans and Light Trucks 1991*, published by the U.S. Federal Highway Administration (Report No. FHWA-PL-92-019) estimates nine cost categories for eight vehicle classes. This report used a 12 year average vehicle life to calculate life cycle costs, which is more appropriate for policy studies than the 6 year life used by AAA in its estimates. The report includes tables that show each cost for each year, and broken down into ownership and operating costs. The total average total costs are:

Subcompact	28.9 cents per mile
Compact	29.5
Intermediate	33.4
Full Size	37.9
Compact Pickup	30.6
Full-size Pickup	35.1
Minivan	35.3
Full-size Van	44.8

These figures should be adjusted for inflation and for changes in the relative prices of the different components. The figures should be increased by roughly 20 percent to convert them to 1999 prices. Since depreciation and finance charges are the greatest fixed expenses, older vehicles will have lower fixed costs and higher maintenance costs.

[59] This conclusion, based on economic theory, is supported by the findings of an international study commissioned for the World Bank. The study found that over-investment in roads can drag down a national economy. Kenworthy,

The environmental and social costs of driving can be high.[60] Few would deny that the transportation system's congestion or environmental impacts are important to the well being of citizens and the functioning of the economy. However, they also are difficult to quantify and not everybody accepts their responsibility for these costs. At this initial stage of analyzing transportation policy, DEQ has chosen to concentrate on financial costs, cash-out-of-pocket costs people already realize that they pay.

The total cost of owning and operating a vehicle can be divided into fixed and variable costs. Fixed costs, which make up the greatest share of total costs, are, for the most part, independent of the miles driven. At present, those include fire, theft, collision, and liability insurance; license, registration, and taxes; and depreciation and finance charges. (However, some of these fixed costs of driving have a value that actually depends on how much one drives.) The variable costs vary with the amount of driving done. These costs, which include gas, oil, maintenance, and tire costs, are quite low, and make up only a small portion of the total costs of owning and operating a car. The cost of fuel is the only variable cost that significantly affects our driving habits. Gasoline costs less, in some cases far less, than $0.10 per mile for most cars and generally makes up only 10-20 percent of the total costs of owning and operating a typical car.

Other costs are picked up through revenue sources other than the fees and taxes users pay. The more prominent of these are local street or road costs paid through taxes and fees on property. Often this subsidization is justified by the ease of administration or the connection to a perceived benefit such as access to the transportation network (but see section on property owners' contribution to the network, p. 1). However, this gives misleading signals to drivers about the true cost of their choice to drive more or to drive less.

Overall, shifting driving-generated costs on to driving behavior will reduce the long-run demand for transportation compared to what it would have been with the subsidies currently embedded in the system. Shifting those costs increases economic efficiency because decisions made in the marketplace take better account of the true cost of those decisions. Drivers will have greater incentive to evaluate their consumption relative to their needs and make appropriate choices. Resource efficient modes and travel patterns, ones different than those dominant today, will become more competitive.

A significant benefit of policies tied to prices is that drivers are encouraged to reduce driving that they themselves, and not bureaucrats or legislators, consider the least valuable. Methods that signal the cost of driving include road pricing (such as extra charges to drive on roads likely to be congested), fees based on VMT, and fuel taxes.

Because of the lack of alternate routes or modes of travel in most Montana cities, road pricing may not be appropriate in most parts of the state. VMT pricing would be easier to implement in those states where, unlike in Montana, a system to assess the amount of travel already exists.[61]

Jeff, Felix Laube, Peter Newman and Paul Barter. *Indicators of Transport Efficiency in 37 Global Cities*. A report for the World Bank, February 1997. Available from ISTP Publications.

[60] See, for instance, Federal Railroad Administration. *Environmental Externalities and Social Costs of Transportation Systems--Measurement, Mitigation and Costing: An Annotated Bibliography*. August 1993.

[61] An inspection and maintenance program to prevent pollution would be an example of such a system.

Because a fuel tax collection system already is in place, increases in fuel taxes would be the easiest way in Montana to make the cost of a trip better reflect the true costs of driving.

It is not necessary to raise the total cost to the public of driving to change the perceived cost of driving. Asking drivers to pay more of the costs of road construction and maintenance, as well as the costs of related services and fuel, doesn't change those costs. By shifting costs now paid through property taxes or other fees onto fuel taxes or other fees that vary directly with use, what you pay for transportation would be better connected with what you use. In practice, most people would see a shift of costs from one aspect of their life to another (driving costs go up, property taxes go down). Who benefits and who doesn't depends on who was getting a subsidy previously (see section on distributional impacts, p. 1).

Economists agree that the amount of driving changes with the cost of fuel. They don't agree on how big a change will come from a given change in the cost of making a trip. This response is estimated by the elasticity of VMT with respect to its variable cost, that is, the percent change in VMT associated with a certain percent change in user costs per mile. An FHWA report cites findings of long-run elasticities of -0.20 to nearly -1.00.[62] This means that a 10 percent increase in fuel costs could lead to anything from 2 percent to almost 10 percent reduction in the number of miles traveled. The more recent studies suggest the elasticity for driving is toward the lower end of this range. The surge in driving in response to lower fuel prices in 1998 clearly demonstrates that the amount people are willing to drive responds to fuel price.[63]

Resolving these differences among economists is not critical to this analysis. First, since reducing existing incentives for inefficient driving should improve the state's economy, Montanans overall will be better off to some degree, even if the change in VMT can't be specified in advance. Second, changes in VMT are not the same as changes in fuel use. Faced with higher fuel prices, some people will choose to operate vehicles that are more efficient rather than do less driving. Therefore, one expects the amount of greenhouse gas emissions to drop faster than VMT. Third, as FHWA observes: "Even if the elasticity of VMT with respect to gasoline prices is small, the impact of gasoline taxes may be significant relative to other policy instruments, since the emission reduction benefits are realized across the entire motor fleet."[64]

Most of the costs that could reasonably be shifted to fuel taxes currently are costs that currently are funded by earmarked revenues. Much of those revenues go to city and county governments. Determining how to allocate fuel taxes to these costs will require thoughtful consideration. In particular, the ability of local governments to provide services should not be compromised by shifting transportation costs to fuel taxes.

More analysis than is provided here will be necessary to set fuel tax increases at a level that is effective and politically acceptable. There is some room for error, at least in terms of Montana

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[62] Federal Highway Administration. *Transportation and Global Climate Change: A Review and Analysis of the Literature*. June 1998. p.32.

[63] "Unanticipated Gas Tax Rolling In" Great Falls Tribune, 2-3-99, p.2.

[64] Federal Highway Administration. *Transportation and Global Climate Change: A Review and Analysis of the Literature*. June 1998. p.38.

politics, in that a large percentage of any fuel tax is paid by non-residents.[65] The bottom line, though, is that the intent of these proposed fuel taxes is not to change the cost of driving, but to make it more visible.

2.3.2 Impacts of redistribution of transportation costs

Several of the proposals in this chapter would lead to more of the costs of transportation services being collected via fuel taxes, and less through property taxes, special assessments and fees. While these proposals would not increase the total amount collected, shifting revenue collection from property taxes, assessments and fees to fuel taxes will impact members of society differently. Fuel taxes can be criticized from the standpoint of equity. Fuel taxes tend to be regressive in nature; that is, lower-income households and individuals tend to pay a larger percentage of their income for fuel taxes than do higher-income households and individuals. However, property taxes, at least residential property taxes, likewise tend to be regressive in practice.[66] Since property taxes need not track the taxpayer's ability to pay, these taxes are especially regressive in areas where property values have been appreciating.[67] Those on fixed incomes, such as the elderly, may be affected substantially by rising taxes driven by rising property valuations.

Although both fuel and property taxes tend to be regressive, there is a net gain in economic efficiency by collecting more of the transportation system costs through fuel taxes. Those who use the system more pay more; those who use less pay less. Property taxes do not carry this public policy/economic efficiency advantage of providing these kinds of signals to transportation users.

Though economic efficiency will be improved, there will be “winners” and “losers” due to such changes. Most Montana households and businesses would be winners. Shifting road-related costs from property taxes (including those on vehicles) and registration fees to fuel taxes would require an increase in fuel tax of $0.239 per gallon, if the amount of fuel taxes currently allocated to roads were to remain unchanged. In 1996, such an increase in fuel tax would have allowed reductions in taxes, assessments and fees equivalent to 8.7 percent of all property taxes, and would have virtually eliminated basic licensing and registration fees for all Montanans. This seems unlikely to be more regressive, and may be less regressive, than the current arrangement.

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[65] According to the Institute for Tourism and Recreation Research the amount of gasoline and diesel purchased by non-residents in Montana is estimated at 219 million gallons in 1996, based on survey data (Kristin Aldred Cheek and Rita Black. *Nonresident Travel in Montana: Putting the Numbers into Context*. Technical Completion Report 98-2. University of Montana, June 1998, pp. 15-16). This estimate implies that non-residents used 36 percent of the highway fuel consumed in 1996. The ITRR analysis did not include people traveling in commercial trucks or other commercially marked vehicles. Given reasonable assumptions about the amount of fuel used by Montana households and by commercial vehicles, ITRR’s estimate seems high. With commercial vehicle fuel use added in, it appears reasonable to assume that non-residents accounted for around one-third of the total fuel use. (Of those non-residents that were surveyed, only about one-quarter were simply driving through the state—“bridge traffic.” Most of the non-residents had Montana destinations, primarily for tourism.)

[66] This discussion may not apply to commercial property, especially properties appraised using an income-generation model.

[67] Probably the least discrepancy is found in cases where the property was purchased recently.

One "loser" might be households whose members travel more. However, nationally at least, these households tend to be higher income households, which can better afford increases in vehicle fuel tax. The 1990 Nationwide Personal Transportation Survey shows that households earning more than $40,000 per year traveled 3.7 times more than did households with annual incomes of $10,000 or less.[68] Lower income households were more likely to use public transportation (3.7 percent) and to walk to their destination or use other means (26 percent) than were higher income households (1.2 percent and 7.8 percent respectively). Lower income households used private vehicles (70 percent) far less for trips than higher income households (91 percent).

Of course, increasing the fuel tax would increase the cost of importing and exporting goods in Montana. This increase in cost seems modest. For instance, for a large combination truck getting 4 mpg, and traveling the width of Montana (<700 miles), the suggested fuel tax increase would add about $40 to the cost, or a few tenths of a cent per pound of cargo. For most points in Montana, the cost would most likely be lower. Most Montana families would clearly benefit from the suggested shift in road costs, even considering the extra cost of shipping. Firms using local goods and services to compete against imported products obviously would benefit. Montana firms exporting goods may or may not benefit, depending on whether the reduction in their property taxes and vehicle fees balances the increase in their shipping fees.

Most significantly, if more of the cost of transportation system is assigned to the users through fuel taxes, a larger share of the costs will be picked up by non-resident drivers. Concerns about distributional equity appear to be less relevant for this group. (See chart, next page.) On average travelers to Montana tend to have higher incomes than state residents. Data from the 1995 American Travel Survey, a study by the U.S. Bureau of Transportation Statistics on 80,000 households, provides a breakdown of travelers to Montana by income range.[69] The profile of household income for travelers from the other 50 states shows a noticeably higher income than that of Montanans who travel in Montana.

Based upon a breakout of the Montana data, the largest source of visitors to Montana is Wyoming with 21 percent of all visitors, then California with 17 percent, Washington with 13 percent, Idaho with 9 percent, and Utah with 7 percent. The median income of visitors ranged from $37,000 for people from Wyoming to $62,000 for people from California.

Although distributional equity may not be an issue, there is a legitimate concern that increasing the fuel tax could affect the tourism industry, one of the growth areas in the Montana economy.[70] This concern would exist even if the problem were more one of public relations than economics.

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[68] Hu, Patricia and Jennifer Young. *1990 NPTS Databook: Nationwide Personal Transportation Survey***.** Center for Transportation Analysis, Energy Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, pp.4-54—4-57.

[69] As reported in Black, Rita J. *A National Study of Domestic Travel: Results for Montana***.** Technical Completion Report 98-1. The Institute for Tourism and Recreation Research, University of Montana, Missoula MT, May 1998, pp. 1-2. Note that the data from U.S. DoC study does not include people passing through the state on their way to another destination, but only travelers whose destination is Montana.

[70] This discussion based on a memo from Dave Cole, Department of Commerce, to Paul Cartwright, DEQ, September 28, 1999, and subsequent conversations with the Community Development Bureau.

The suggested increase in fuel taxes would raise the cost of most trips to Montana by out-of-state visitors by $10 or less. This in itself should not be enough to deter travelers. For instance, in the last 12 months, the average cost of gasoline in the Rocky Mountain states has risen from $1.104 to $1.367 per gallon, an increase in cost greater than suggested in this chapter.[71] During the first six months of this year alone, collections of the "bed tax", which tends to follow the amount of tourism, increased by 5 percent over the comparable period in 1998.[72] This suggests that the tourism industry can ride out some increases in vehicle fuel tax. However, the threat of a public relations problem is a real one. Were some national group to whip up resentment against an increase in the Montana vehicle fuel tax, the short-term damage could affect some parts of the tourism industry, and certainly would affect state politics. An effort to set the increase in context, such as by advertising Montana's lack of a sales tax, might be necessary.

While fuel taxes do have equity problems, it is not clear that shifting from property taxes will increase equity problems overall.

Comparison of Household Incomes: Travelers from other states traveling in Montana, Montanans traveling in Montana and Montanans traveling elsewhere in the U.S.*

Household Income	Percent of the travelers from all 50 states traveling within MT	Percent of the travelers from MT traveling within MT	Percent of the travelers from MT traveling in US
Less than $25,000	19	20	21
$25,000 - $39,999	18	31	29
$40,000 - $49,999	17	27	27
$50,000 - $59,999	12	9	9
$60,000 - $74,999	16	5	6
$75,000 - $99,999	8	6	3
$100,000 or more	11	3	5

* *Household Income Profile of Travelers from the 1995 American Travel Survey,* Bureau of Transportation Statistics, U.S. Dept. of Commerce

2.3.3 Funding locally-administered road construction and maintenance

Most of the roads in Montana are maintained by local governments. Cities, towns and counties rely heavily on locally generated revenues, mainly from taxes and fees on property. Local governments rely almost exclusively on locally generated revenue for maintaining smaller roads, such as found in residential areas. This contrasts with the major roads in Montana, which are maintained (and built) using federal and state fuel taxes.

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71 "Motor Gasoline Watch, October 4, 1999." U.S. Energy Information Administration.

72 "Collections from hotel-motel tax rise 5 percent." *Helena Independent-Record*, October 8, 1999. p.6A.

In 1996, counties levied $17.9 million in road taxes and $7.0 million in bridge taxes. They spent another $1.0 million out of their general funds. This $25.9 million was equal to 19 percent of the property taxes counties collected.[73] City and town governments spending on road and street maintenance included $13.3 million paid by local property owners.[74] Some of this came from property taxes and some came from special assessments on property. This $13.3 million in taxes and assessments is equivalent to 23 percent of general fund property tax cities and towns collected in 1996.[75] This does not include road payments made through special improvement districts (SID), payments made for lighting districts, or anything other than items specifically budgeted for roads. The $39.2 million in property taxes and special assessments that local governments spent on road and street maintenance was equivalent to 5.4 percent of all the property taxes collected in Montana in 1996.[76]

Objections to shifting taxes might be raised because property owners as well as drivers benefit from having usable roads. Property owners gain access to their property, which makes it more valuable. These objections overlook the substantial amount that property owners already contribute to the road network. The construction of locally administered roads for the most part is initially paid for by the abutting property owner. This is particularly true in residential areas, where developers must build the roads and recoup their costs in the price of the property. Property owners, at least in areas with street lighting, contribute to the operation of the roads by providing for the lighting. Payments for lighting can be substantial.[77] At present, property owners appear to be carrying a disproportionate share of the costs of roads.

This imbalance exists even though use of locally administered roads generates sufficient revenue to more than pay for the maintenance and improvement of those roads. This is obvious even if one only considers local roads, the lowest category of roads. These roads generated nearly $40 million in state fuel tax revenues in 1996.[78] In contrast, city and county governments received back $17 million in state gas tax revenues to use for work on *all* roads for which local governments were responsible, which included urban system and secondary roads as well as local roads. Because of the way data are reported, it's difficult to say how each local

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[73] Montana Department of Revenue. *Biennial Report, 1994-1996*, p.39 for county road and bridge tax collections. General fund expenditures taken from Montana Department of Commerce local government audit database as of December 29, 1998.

[74] Montana Department of Revenue. *Biennial Report, 1994-1996*, p.39 for cities and towns general fund tax collections. General fund expenditures taken from Montana Department of Commerce local government audit database, as of December 29, 1998. The $13.3 million figure excludes the $1.0 million spent by the combined city-county governments of Butte-Silver Bow and Anaconda-Deer Lodge.

[75] General property tax collections were used as the basis of comparison, since many people are familiar with this tax. The reductions actually would be spread across property tax and one or more special assessments.

[76] The figure used for total property tax collections excluded city SIDs.

[77] In Billings, for instance, SIDs for lighting collect almost half as much as the city spends in general funds on roads.

[78] Number of gallons consumed on local roads was estimated from data in Montana Department of Transportation *Traffic by Sections, 1997*, assuming average fleet efficiency on these roads is equal to 15 miles per gallon, the observed efficiency calculated by dividing vehicle miles traveled by gallons of fuel sold for highway use. This estimate of the number of gallons consumed should be taken as approximate. Estimates of the amount of traffic on local roads have had problems previously, though that appears to be less the case in recent years.

government, or even each category of government, fares. The data are easiest to interpret for the urban areas centered on the 14 largest cities, whose roads generate at least twice as much state fuel tax as is returned to those cities. An allocation of fuel tax revenues based on the principle of user pay" would provide more than enough money to eliminate reliance on property taxes to maintain local roads.[79]

Shifting local road maintenance from property taxes to fuel taxes would have added $0.064/gallon in 1996.

Conclusion: Shifting local road maintenance from property taxes to fuel taxes would give drivers a clearer signal on the actual cost of driving. It also could lead to a reduction in taxes levied by local governments.

2.3.4 Funding construction of major roads

Though property owners currently subsidize drivers on local roads, this may not be the case on major roads. It may be appropriate for property owners to become more involved in funding those roads. There is a growing body of literature that suggests new roads in the U.S. don't expand the economy but merely determine where the growth occurs.[80] Therefore, only the nearby property owners, and not the wider economy, derive benefits from a new road. Therefore, one could argue that a greater proportion of the costs of new major roads should be provided by the areas that stand to benefit from those roads. Making locals bear more of the actual cost of highway development could make other policy options, such as funding alternative modes, more attractive. Faced with more of the actual cost, locals could opt for other options than new roads, all of which are more likely to be more fuel-efficient than current arrangements.

Because the literature on roads and economic development is not yet definitive, the option of using property assessments as part of the funding for construction of major roads should be held for consideration at some time in the future. It's possible that other states will develop policies to recapture some of the benefits created by the construction of new roads.[81]

Conclusion: The literature on roads and economic development does not yet justify revising tax policies to shift some of the costs of major roads to benefiting properties; however, it might at some time in the future.

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[79] Although both city and county residents would benefit by shifting the costs of roads and property taxes to fuel taxes, city residents appear to benefit more. This would lower the relative cost of living in cities and thereby reduce one of the incentives to sprawl development. Thus, shifting existing costs of driving could reduce greenhouse gas emissions in two ways.

[80] See, for instance, Marlon Boarnet. "Highways and Economic Productivity: Interpreting Recent Evidence," *Journal of Planning Literature*, Vol. 11, #4, pp. 476-486, May 1997. "Recent evidence suggests that, at the margin, highway infrastructure contributes little to state or national productivity…. Yet, the idea that highways enhance economic health is common in the policy and planning communities. …Part of the reason for this disconnect is that when growth occurs along a new highway, people fail to acknowledge that part of that activity shifted from somewhere else within a region." That new roads no longer contribute as much to economic growth makes sense when one considers that the road network in the U.S. already is very dense and of high quality.

[81] See, for instance, the study on corridor reservation by Robert J. Borhart, Implications for Recouping a Portion of the "Unearned Increment" Arising From Construction of Transportation Facilities. Virginia Transportation Research Council. Charlottesville, Virginia. January 1994. (VTRC 94-Rl5).

2.3.5 Funding for road-related police, fire and court services

Local road maintenance and improvements are not the only road-related expenses funded by property taxes. A portion of police, fire and local court services are provided specifically for drivers. A study of two Montana cities and counties suggested the cost of these services could be substantial.[82] The study found that for the two cities, the cost of funding fire, police and court services related to road use was equivalent to 58 percent of property taxes collected by those cities.[83] For the two counties, the figure was 7 percent of all the property taxes they collected.[84] If the experience of these four governments is representative, then local governments spent in the neighborhood of $40 million on road-related police, emergency response (fire department) and court services in 1996.

This suggests that drivers could reasonably be asked to pay as much as $0.07 per gallon for road-related police, fire and court services. Because of the limits of the data, this figure should be taken as merely illustrative. A figure of $0.04 per gallon would not over-state the costs incurred. Receipts from this tax could be used to reduce property taxes by 3.3 percent.

Conclusion: Road-related local fire, police and court services are a substantial cost to local taxpayers. Further study is necessary to determine exactly how large that cost is. Shifting these costs to drivers would permit a reduction in local government tax assessments.

2.3.6 Registration and license fees

In 1997, Montana collected over $130 million in fees and taxes for on- and off-road motor vehicles.[85] The majority of those were based on the value of the vehicle. Some, such as for personalized license plates, were optional.

Fixed fees are fees that must be paid irrespective of the amount of driving done or the type of car owned. The fixed fees collected in 1997 were:

Registration fee	-	$5,294,302
License fee	-	8,392,667
Junk	-	395,981
Weed (highway)	-	1,343,390
Hwy patrol retirement	-	265,990
System fee*	-	800,000
TOTAL	-	$16,492,330

*Estimated total excludes non-highway vehicles

[82] Alternative Energy Resources Organization. *Big Sky or Big Sprawl: What Transportation and Land-Use Decisions Cost Montana Communities*. October 1996.

[83] Again, property tax collections were used as a basis of comparison. A significant portion of money used for these functions actually comes from department-generated revenues or other sources, such as gambling taxes and city-issued licenses.

[84] Note that cities fund more of their operations through special assessments (which technically are not property taxes) than do county governments. Therefore, using property taxes as the basis of comparison overstates the reduction city residents will see vis a vis that seen by county residents.

[85] Data from Motor Vehicle Division, Department of Justice, January 1999.

One could argue that the value of having a vehicle licensed and titled is connected to how much it is used. Shifting the non-variable portion of registration and licensing fees would have required an average of $0.026/gallon fuel tax in 1997.[86]

Property taxes historically have been levied on the market value of a vehicle, but that is changing. At the beginning of 1998, heavy truck owners started paying a fee in lieu of property taxes, based on the age and weight of the truck. During the 1999 legislative session, property taxes on cars and light trucks were cut thirty percent. In addition, a proposal will be put to the voters in 2000 to go to a flat fee (based on age of vehicle) in lieu of property taxes. If taxes based on the value of the vehicle change to something based on the simple ownership of a vehicle, shifting to a fuel tax could be appropriate, since the value depends on the amount of use. On average, the older a vehicle is the less it is used, so a tax on fuel consumption would generally parallel a fee based on age. Under either the fee in lieu or the fuel tax, the amount paid would decrease as the vehicle got older; however, for some vehicles, the amount paid in fuel tax could be greater than the amount paid as a fee in lieu. In 1997, $68.7 million was collected in vehicle property taxes. Actions by the 1999 Legislature will lower this amount in the future. Those actions have created a shortfall in funding for local governments, which relied on vehicle property tax revenue. Some but not all of this shortfall will be made up by the state government. Shifting the amount previously collected through property taxes to fuel taxes in 1997 would have required an average of $0.109/gallon fuel tax.[87]

Conclusion: Shifting fixed fees and property tax to fuel taxes would reduce the total collected for licensing and registering vehicles of all types by two-thirds. For many car and light truck owners, these costs would drop to near zero. Under the current system, licensing and registration costs must be paid in a lump sum once a year. In contrast, collecting those costs through fuel taxes would be spread over the year, which many households would find easier to handle.

2.3.7 Government support for the petroleum industry

The federal and state governments provide a number of tax breaks, service programs and direct support for the petroleum industry. Many believe these are subsidies, while others do not. Because the price of oil is set by the world market, for the most part these federal interventions are more likely to affect the profitability of the U.S. petroleum industry than the cost of petroleum products. Therefore, while changing these subsidies might benefit the country's environment or the national economy, the changes probably wouldn't affect the emission of greenhouse gases.

One obvious exception is the Strategic Petroleum Reserve (SPR).[88] The SPR was created in 1975 to protect the United States from oil supply shocks that could result from political, military,

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[86] Because diesel fuel vehicles tend to use more fuel per mile traveled, a slightly higher addition to gasoline tax and a slightly lower addition to diesel fuel tax would be appropriate.

[87] The lowest property tax assessed on any vehicle is the $10 assessed on older cars and light trucks. To reduce fees in lieu of property taxes $10 for each vehicle would have required a $0.016/per gallon tax.

[88] One other, and much more complicated, exception is the military expenditures to protect oil reserves in the Persian Gulf and elsewhere. Many commentators have argued that some portion of these costs should be charged directly to petroleum consumers since they, rather than the entire economy, benefit from these efforts. Without this

or natural causes. The storage capacity of the Strategic Petroleum Reserve, as of 1995, was 680 million barrels.

The subsidy comes primarily from building and maintaining the SPR. At least part of the cost of buying the oil could be recovered when the oil is sold; however, because the price of oil has dropped since the SPR was filled, the SPR currently shows a paper loss. Once the oil is sold, the size of that portion of the subsidy will be known. The larger subsidy comes from the interest charges on the money the Treasury had to borrow to build the facility and to buy and hold the oil for a long and—so far—indeterminate length of time. One authority estimates the cost of maintaining this large supply of oil at $1.6 to $5.4 billion a year, excluding unrecognized declines in asset and inventory values.[89] In 1995, this would have been equivalent to a national subsidy of $0.006 to $0.020 per gallon of petroleum product.

It is possible that SPR can only exist as a government service. By protecting consumers and refiners from oil market disruptions, the SPR does benefit the economy. However, it disproportionately benefits inefficient companies and oil-intensive sectors compared with other companies or sectors. It reduces the need for refiners and consumers to create or expand their own storage and the incentives for consumers to increase their ability to shift fuels in times of oil shortages.

Conclusion: Since oil consumers benefit more directly from the Strategic Petroleum Reserve than does the general taxpayer, it seems appropriate that they pay the cost of providing the SPR.

2.3.8 Pay-at-the-pump insurance[90]

Montana could institute a privately underwritten motorcycle, automobile, and light truck liability insurance system in which the premiums are collected through fuel taxes, a portion of motor vehicle registration fees, and surcharges on fines for certain traffic violations**.** This type of auto liability insurance program often is referred to as pay-at-the-pump insurance even though some of the premiums are collected elsewhere. Pay-at-the-pump auto insurance is one way to encourage energy and cost savings by shifting a portion of a fixed cost—liability insurance—to a variable cost. Premiums collected at the pump would make up a substantial portion of the total funds needed, though not necessarily a majority.

Any pay-at-the-pump insurance program will raise equity questions about the appropriate balance between premiums collected at the pump and the amount each individual contributes toward insurance premiums. The gas pump charge would ensure that persons who drive more or who use heavier vehicles, which generally are less efficient and which tend to be more dangerous to other drivers, would pay more for insurance than those who drive less. Amounts ranging from $0.10 to $0.50 per gallon have been suggested in pay-at-the-pump proposals made in other

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military support, relying on petroleum products would be much more risky, while investments in efficiency and renewables would be much more attractive.

[89] Douglas Koplow and Aaron Martin. *Fueling Global Warming: Federal Subsidies to Oil in the United States*. Industrial Economics, Incorporated. For Greenpeace, Washington, D.C., 1998.

[90] Parts of this discussion are based on the Vermont state energy and greenhouse gas plan, *Fueling Vermont's Future.* Vol.2, pp.4-181/188. July 1998.

states. A tax of $0.18 per gallon would have covered half the liability premiums paid in Montana in 1997.[91]

A surcharge on certain traffic fines would address the questions about the variation in the safety of individual drivers' behavior. The equity issues related to these varying risks can be resolved by matching the risk of crashes with surcharges on the violations most often related to crashes, such as speeding, careless and negligent driving and driving while under the influence of alcohol. The surcharge would vary depending on the severity of the infraction. The surcharges on operating violations and on criminal traffic violations would need to be substantial, possibly several thousand dollars for the more serious violations, to cover the actuarial risks. It is important to remember, however, that the surcharges represent a one-time cost. Currently, insurance premium increases due to these offenses are less per year than a surcharge might be, but premiums generally remain high for three or more years following a violation or conviction. Payment plans could be used to spread the costs out over time as occurs now, which would alleviate some of the financial burdens caused by the surcharges.

The remaining amount needed for auto liability premiums would be assessed each year at the time of registration or licensing. The registration premium would be calculated using characteristics of the vehicle (such as purchase value, age, size, or type), its use (such as for business), and characteristics of the owner (such as owner's driving record).

At the time of registration, motorcycles, cars, and light trucks would be grouped into blocks of several thousand that are representative of the Montana driving population and vehicles. Private insurance companies would bid on these groups. The company winning the bid would be paid from an account that held the gas pump premiums, violation surcharges, and registration premiums. Vehicle owners could purchase additional liability insurance or comprehensive and collision insurance if they desired.

In addition to the cost and energy savings, there also are insurance advantages to a pay-at-the-pump liability insurance. It would eliminate the problem of uninsured motorists in Montana. Currently, Montanans who purchase insurance bear the costs of under- and uninsured motorists. Pay-at-the-pump insurance would thereby lower insurance costs for drivers, saving them money. It would eliminate some sales and some underwriting costs of auto liability insurance. Additional savings might come from competition among insurance companies bidding for group insurance plans.

Pay-at-the-pump insurance does change government's role in vehicle insurance, but possibly not to as great an extent as some may perceive. First, pay-at-the-pump insurance relies on private insurers to underwrite the policies. The state would have the minimal roles of collecting premiums through existing mechanisms (with gas taxes, traffic fines, and registration fees), overseeing the bidding process, and ensuring that the obligations of the contract are fulfilled. Second, auto liability insurance is already required by law, which includes the requirement of specific minimum coverage. Third, Montanans would still be free to purchase additional coverage as they wish, either at the time of registration or from an insurance agent.

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[91] The total premiums paid for liability insurance for private and commercial vehicles in 1997 was $224,045,867. E-mail from Jennifer Phillips, State Auditor's Office, June 29, 1999.

Establishing a pay-at-the-pump insurance program could be difficult and complex. The insurance industry has not shown any interest in promoting such programs. While pay-at-the-pump insurance has been discussed in several states, no state has adopted it. Pay-at-the-pump insurance, and the related matter of uninsured motorists, are not presently issues attracting much attention in Montana.

Conclusion: Pay-at-the-pump insurance probably should not be included as one of the first steps in dealing with greenhouse gas emissions in Montana.

2.3.9 Other variable pricing options: Cashing out parking

Nationwide, 94 percent of automobile commuters park their cars at work for free.[92] However, free parking is not free: someone must pay for that parking, including the cost of renting or purchasing the land, paving and maintaining the lot, providing lighting and removing snow. People using "free parking" pay either in the form of reduced wages or benefits (workers), increased costs for goods and services (consumers) or higher costs for homes or apartments (residents).[93] When employers pay the costs associated with "free parking," they subsidize the use of automobiles. Nationally, driving to work accounts for about one-third of vehicle miles traveled. Therefore, Montana's businesses and governments are subsidizing a major portion of the automobile travel in Montana.[94]

To expect these businesses or governments to subsidize gasoline for employee commuting would be absurd, but they often pay an equal or greater amount for employee parking. One way to remove the subsidy is to charge drivers some part of the cost of parking. A commute of 15 miles round trip in an average car costs about $1.00 in gasoline. If parking costs of $1.00 per day (considerably less than the actual cost of space in a surface lot) were added to what drivers pay for fuel, the variable cost of driving would double. Without raising the total cost of driving, transferring parking costs to drivers would send a clearer market signal, encouraging some drivers to use alternatives that are more efficient.

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[92] Shoup, Donald C. "Congress Okays Cash Out." *Access* (Fall 1998), 1998. p.2.

[93] One exception to this observation is high school students, who pay little directly, and nothing indirectly, except that the tax money subsidizing student parking reduces the amount available for education. For instance, students in Helena pay $5 a year for parking, easily less than 10 percent the cost of a parking space. Maintenance alone on the school lots probably costs on the order of $90 per year per space, based on recent City of Helena experience for surface lots (Helena Parking Commission. *Parking Management Plan and Capital Improvements Program—1996)*. As for capital cost, the Helena High School District recently budgeted $620,000 for rebuilding existing lots containing 1,100 spaces. Given the current structure of our cities, student parking is a necessity, but its subsidization is not. Dropping parking subsidies would reduce school demands for property taxes. It also would reduce morning rush hour congestion. In Helena, the number of high school student drivers equals over 3 percent of the total number of persons employed within the city limits. They obviously impact the flow of morning traffic. Property owners who subsidize parking also are subsidizing the congestion they must drive through.

[94] Subsidizing parking also subsidizes certain property owners and penalizes others. Subsidized parking lowers the apparent cost of driving, making the cost of living outside of cities look lower and the value of suburban land look greater. Conversely, subsidized parking reduces one of the benefits of living in town (transit, walking or biking as viable alternatives to driving) and thereby lowers the value of urban land.

Charging for parking, however, is unlikely to be popular. Employer-paid parking is the most common tax-exempt fringe benefit in the United States.[95] It may be dubious public policy, but it is expected. The alternative, which DEQ believes would be more acceptable, is to expand the definition of the benefit, making it a transportation benefit. At very least, all employers who lease parking should be encouraged to offer alternatives to free parking benefits.

Changes in federal law now allow employees to choose to receive cash or other compensation in lieu of qualified parking benefits.[96] Employees may choose between taxable compensation and tax-free parking benefits, up to the statutory limit, currently $170 per month. (Similar tax-free benefits are available for transit riders and van pool users.[97]) Some employers who pay parking costs will find it cheaper to give employees the cash value of their fringe benefit, with the employee choosing whether the parking space is more valuable than the cash. This choice, even though taxable, may appeal to workers in those sections of Montana cities where alternatives to driving solo exist. Case studies suggest that, depending on the cost and difficulty of finding parking, switching to pay for parking reduces parking needs by as much as one-quarter.[98]

Most employees still will opt to take their benefit in the form of a parking space. However, some employees will join together in car pools, splitting the cost of parking and pocketing the rest of the money. Others will walk or bike. These people will receive cash for their part in reducing the parking and congestion problems. Because some people already car pool, walk, or bike, and therefore would not free an additional parking space, the cash out benefit should be set lower than the cost of a parking space. In addition, small administrative costs such as issuing vouchers, cashing vouchers and enforcement must be accounted for.

Montana probably does not have as many opportunities for parking cash-out as do states with larger urban areas. However, the policy could still benefit employers and employees alike, as well as produce public benefits. Not the least of these benefits would be a demonstration that alternatives to solo driving exist and can be acceptable. The state could take the lead, setting up a program to cash out spaces it now leases. General Services Division central office only has records of 132 leased spaces, at prices ranging from $12 per month to $31.35 per month.[99] However, an unknown number of other spaces are leased directly by the agencies themselves or are buried within building leases. An initial program could address the more expensive spaces in Helena, and possibly Bozeman, Missoula and Billings, where the program could be combined with parking leased by the universities. The state also could work with federal and local governments to establish cash-out programs. Unions and associations of private employers in the larger cities could be provided informational materials, based on the state's experience.

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[95]Shoup, Donald C. "Congress Okays Cash Out." *Access* (Fall 1998), 1998. p.2.

[96] The Taxpayer Relief Act of 1997 and the Transportation Equity Act for the 21st Century amended 26 USC 132(f)(4) of the Internal Revenue Code.

[97] Commuter Check Services Corp. (CCSC), a private company that operates transit fare discount programs for local agencies, has a website that describes the transit tax benefits.

[98] This suggests that employer subsidized parking is wasteful because employees are not willing to pay as much as employers for parking spaces. Shoup, D.C. "An Opportunity to Reduce Minimum Parking Requirements." *APA Journal*, 61,(1,Winter), 1995. p.18.

[99] E-mail from Garett Bacon, Department of Administration, January 2, 1999.

Conclusion: There are some opportunities in Montana for the public and private sector to offer their employees the option of cashing out their parking spaces.

2.4 Improving vehicle efficiency

The amount of fuel used for transportation can be reduced by encouraging drivers to purchase efficient cars and to operate them efficiently. Nationally, both regulatory and market-oriented approaches have been suggested. None of them appears to have a significant constituency in Montana at this time.

2.4.1 CAFE standards/efficient vehicles

CAFE (Corporate Average Fuel Efficiency) refers to the average fuel efficiency of the fleet of cars or light trucks made by each manufacturer. Standards requiring a certain level of efficiency are set by the federal government, not the states. The current standards of 27.5 miles per gallon (mpg) for cars and 20.7 mpg for light trucks have not changed significantly since the mid 1980s.[100] In recent years, Congress has blocked any attempt to raise the CAFE standards.

Automakers must meet CAFE standards or face fines of $5 per 0.1 mpg under the standard multiplied by the number of vehicles in the fleet. To avoid paying a fine in a particular year, automakers may carry forward or backward for up to three years any credits ($5 per 0.1 mpg over the standard multiplied by the number of vehicles) to offset fines when the standard is not met. To date only a few small specialty manufacturers have been penalized and fined. Since the CAFE standards only count petroleum-based fuel consumption, manufacturers can improve their fleet fuel efficiency by offering alternative fueled vehicles. With increased sales of sport utility vehicles, the major U.S. car manufacturers may incur penalties for failure to meet the CAFE standards for trucks, although offering alternative fuel models may enable the automakers to continue to offset the penalties. For whatever reason, major manufacturers are offering increasing numbers of alternative fueled vehicles.[101]

The CAFE standards were supposed to set a minimum standard, but they appear to have functioned as a maximum standard as well. Since 1990, the industry has typically exceeded the automobile standard by a little over a mile per gallon, and the truck standard by a few tenths of a mile.[102] With the median age of cars and light duty trucks less than 8 years, and older vehicles driven fewer miles per year than newer ones, most of the benefits of CAFE standards already have been realized.[103] Because the mix in the national fleet is changing, the average efficiency of new vehicles is declining. Between 1990 and 1997, light trucks' share of the new vehicle market rose from 33 to 44 percent. While the average efficiency of new passenger cars actually

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[100] These standards are different from the adjusted values on the stickers of new cars. Those sticker ratings are about 15 percent lower than the EPA figures used for the CAFE standard because the treadmill tests used by EPA don't match current driving conditions and practices.

[101] For instance, all 1999 Ford Explorers and 1999 Chrysler mini-vans with the 3.3 liter engine are, at no extra cost, compatible with E-85 fuel (85 percent ethanol, 15 percent gasoline). The 1999 Ford Taurus can be ordered with E-85 option. There were 20,000 Ford Taurus E-85 flex fuel vehicles produced in both 1997 and 1998.

[102] *Transportation Energy Data Book: Edition 18-1998*. P.6-14.

[103] *Transportation Energy Data Book: Edition 18-1998*. P.5-11.

rose slightly during that time, that of new trucks dipped slightly, and the fleet average for cars and light trucks combined dropped from an EPA fuel economy value of 25.3 mpg to 24.8 mpg.[104] Over that same period, national VMT rose 19.4 percent and national gasoline consumption rose 12.0 percent. For all that CAFE standards improved the efficiency of the U.S. vehicle fleet, they have not been sufficient to stabilize fuel consumption.[105]

The national debate over CAFE standards has been rancorous. Proponents claim that increasing the federal CAFE standards is both technologically and economically feasible.[106] Opponents characterize CAFE standards as expensive an unwarranted intrusion in the market place.[107] National standards, whether set high or low, will affect Montana and therefore Montana should be concerned. However, with less than 0.5 percent of the nation's vehicle fleet, Montana would have to struggle to be heard in debates about the national vehicle fleet. Combining that with some Montanans' antipathy to federal regulations of any kind, supporting CAFE standards as a part of the greenhouse gas action plan does not seem to be a high pay-off strategy.

If Montana was to get involved in promoting change in vehicle design, it could encourage the federal government and the industry to work on developing hypercars. Hypercars will be lightweight cars, made primarily of moldable synthetic composites (such as carbon fibers), with a low-drag design, powered by electric motors using electricity generated on-board. Analysts such as Amory Lovins believe these cars would be capable of traveling 90-200 miles per gallon of gasoline equivalent. In addition to their air-pollution and energy efficiency benefits, hypercars, with their radically different manufacturing techniques, hold the possibility of a decentralized automobile manufacturing industry, which may have its own social and environmental benefits.

The federal government, in cooperation with major automobile manufacturers, started the Partnership for a New Generation of Vehicles in 1993 to move the industry in the direction of hypercars. Using more modest technologies than suggested for hypercars, PNGV has set a goal of concept vehicles capable of providing up to 80 mpg by 2000 and production prototypes by 2004. Car companies may exceed this goal. Toyota offered Prius, the first gasoline-electric hybrid car, for sale in Japan in October 1997; it will begin selling Prius in the U.S. and Europe in

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[104] Oak Ridge National Laboratory, Light-Duty Vehicle MPG and Market Shares System, in *Transportation Energy Data Book: Edition 18—1998*, p.6-4 and p.6-12.

[105] David Greene. "Why CAFE Worked" Oak Ridge National Laboratory, November 6, 1997.

[106] The summary of one study reported that, "After screening technologies for their cost-effectiveness, we estimate that by 2005 average new-car fuel economy can be raised by 65 percent, from 28 to 46 miles per gallon." The authors also found that a comparable increase in efficiency can be made for light trucks. The cost of the automobile efficiency improvements using cost-effective available technology was estimated at $800 per car or about one-third the cost of the average lifetime fuel savings of 2,100 gallons of gasoline. (DeCicco, J. and M. Ross. "Improving Automotive Efficiency" *Scientific American*. December, 1994, pp. 30-35.)

[107] However, not all the dire predictions made in the past have come to pass. When CAFE standards were first suggested in 1974, the Ford Motor Company asserted, "This proposal would require a Ford product line consisting of either all sub-Pinto-sized vehicles or some mix of vehicles ranging from a sub-sub compact to perhaps a Maverick." (Ford Motor Company Statement on S.1903, Hearing on Energy Conservation Working Paper Before the Senate Committee on Commerce, 93rd Congress, 2nd Session, 177)

2000. The Honda Insight will be available in the United States in late 1999. General Motors Corp., Ford Motor Co. and DaimlerChrysler AG also are developing hybrids.

Conclusion: Supporting private and public efforts to create hypercars is the best way for Montana to encourage the manufacture of more efficient vehicles.

2.4.2 Feebates[108]

More market-oriented ways to encourage vehicle energy efficiency include providing incentives to consumers who purchase energy efficient vehicles (rebates), disincentives to consumers who purchase inefficient vehicles (a gas-guzzler tax), or both (feebates) at the time of sale. Feebates, as the most comprehensive option, would provide a long term, market-based incentive to develop and purchase increasingly efficient automobiles, and would help ensure that energy use and emissions are an important factor when transportation vehicle choices are made. Feebates, because they're paid at time of purchase, represent sunk costs, and don't directly affect the amount of driving a person chooses to do. However, they can influence the efficiency of the car a person chooses to drive. DEQ mentions them as an illustration of other pricing mechanisms that change fuel use.

Feebate programs can be revenue neutral, meaning that the total of money collected by the surcharge is equivalent to the money rebated. Feebate programs can apply to new vehicles or new and used vehicles. Existing used cars could be grandfathered out, with the feebate applying only to vehicles that are manufactured after the beginning of the feebate program. The efficiency of cars could be determined using EPA's annual *Fuel Economy Guide*. In addition, the American Council for an Energy Efficient Economy publishes a guide to cars that are particularly efficient for each class of car.[109] This type of program need not put additional burdens on low income drivers, since the most efficient cars to drive (and often the least expensive to purchase) would have no additional fee and would probably receive a rebate.

Assuming Montana follows national patterns, new car and light truck registrations in Montana have been running around 70,000 vehicles per year.[110] DEQ did not identify financial subsidies that could be reduced through implementation of a feebate system.

The feebate concept also could be applied to the purchase of tires. Feebates would be aimed at the replacement tire market. Tire manufacturers now manufacture lower rolling-resistance tires, which can increase fuel economy without sacrificing safety or performance. Newer cars usually come with such tires as original equipment. However, because low rolling-resistance tires are more expensive than other kinds, consumers often replace tires, when worn, with higher rolling-resistance tires. This lowers fuel efficiency and increases greenhouse gas emissions. A

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[108] Parts of this discussion are taken from the Vermont state energy and greenhouse gas plan, *Fueling Vermont's Future.* July 1998. Vol.2, pp.4-224/229.

[109] *Green Guide to Cars and Trucks: Model Year 1999*. ACEEE, 1001 Connecticut Ave., N.W., #801, Washington, D.C., 20036.

[110] Federal Highway Administration. *Historical Statistics, 1996*. p. II-3 and II-5; U.S. Department of Energy. *Transportation Energy Data Book, Edition 18*. p. 5-7. Data on new vehicles being registered in Montana was about half that total, suggesting either that Montana has a much higher proportion of used cars than the national average, or, more likely, that many of the new cars in Montana initially received their title outside of the state.

rebate for purchases of tires that have rolling resistance below a certain level and fees for rolling resistance above that level would encourage sales of low rolling-resistance tires. A feebate on tires may prove more attractive than one on vehicles because people tend to focus more on the practical qualities of tires than vehicles. Besides reducing greenhouse gas emissions, an increase in the use of low-rolling resistance tires could reduce fuel consumption by about 4 percent, a direct benefit to the car operator.[111] At present, Congress has blocked development of any program to label tires for rolling resistance.

Conclusion: Consumers would benefit by Congress allowing the development of tire labels with consumer information on rolling resistance.

2.4.3 Highway speed limits

Changes in highway driving speeds influence the amount of fuel a vehicle uses. Higher speeds increase aerodynamic drag, which causes fuel economy to decline. FHWA estimates that it takes 7 percent more fuel for newer cars and light trucks, and much more for older vehicles, to travel at 75 mph instead of 65 mph.[112] This loss of efficiency is most noticeable on rural interstates, where most of the higher speed driving occurs. In 1997, these roads handled 2,121 million VMT, almost a quarter of all the miles traveled in Montana. Of the Interstate traffic, almost 80 percent of the VMT was by cars or light trucks.[113]

In Montana, typical speeds on rural interstates started climbing during the early 1980s (see chart). This contrasts with the period following the 1973 and 1979 oil price shocks, when Interstate speeds were steady or declining. Typical Interstate speeds increased dramatically when the numerical speed limit was ended in December 1995.[114] With the amount of high speed traffic continuing to increase (see table), fuel consumption can also be expected to increase.[115]

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[111] *Majority Report to the President by the Policy Dialogue Advisory Committee To Recommend Options for Reducing Greenhouse Gas Emissions from Personal Motor Vehicles*. Washington, DC. 1995.

[112]FHWA, as reported in U.S. Department of Energy, Oak Ridge National Laboratory *Transportation Energy Data Book: Edition 18--1998*, p.6-19. The sample on which this estimate is based is small and the estimate should be considered approximate.

[113]MDT *Traffic by Sections 1997.*

[114]This jump shows that, contrary to a common assertion by highway engineers, drivers consider the speed limit as well as the design of the road when they choose the speed to drive.

[115] The amount of pollution generated at high speeds also will increase. Emissions systems (of which catalytic converters are only one part) were largely designed for speeds up to about 55-60 mph. Measurements of automotive emissions have shown a doubling between 50 mph and 70 mph (Popp, Peter J., Gary Bishop and Don Steadman. *On-Road Remote Sensing of Automobile Emissions in the Chicago Area: Year 1, August 1998; Year 2 August 1999*. University of Denver August 1998. Denver, CO, page 16.). These factors are not reflected in current EPA models. Much of recent research on this topic has been part of, or a result of, EPA's study of real-time vehicle emissions since 1991. These studies have resulted in a number of documented violations, where manufacturers have programmed fuel efficiency into electronic systems in ways that defeat emissions reductions. Manufacturers that have settled with EPA include Ford, Caterpillar, Cummins, Navistar, and Chrysler. General Motors, Mitsubishi and Honda have agreed to recall vehicles to correct the vehicles' emissions control systems.

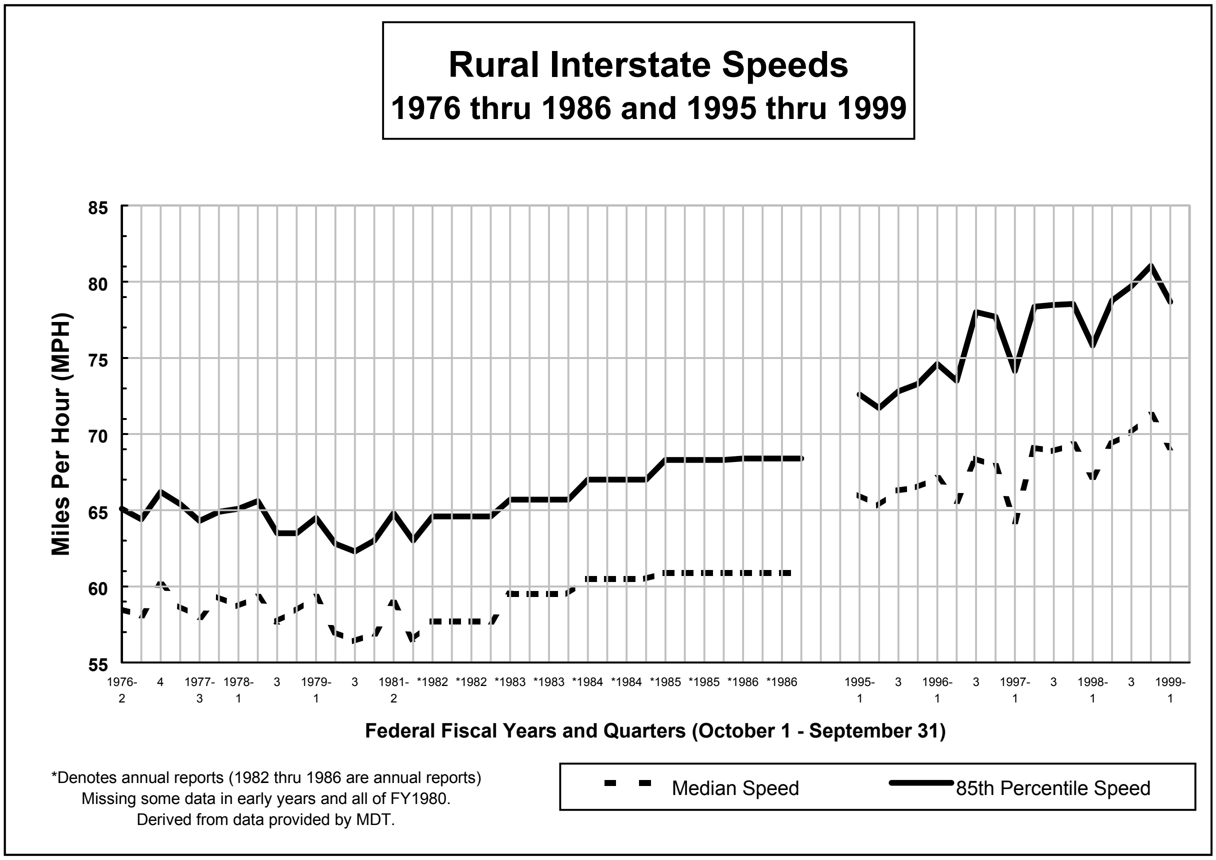

Table: Percentage of vehicles driving faster than a given speed on rural interstates*

Speed	Federal Fiscal Year#		
Mph	1995	1997	1998
>65	50.5%	61.9%	65.6%
>70	19.9%	38.8%	42.3%
>75	5.7%	19.6%	23.2%
>80	1.8%	8.4%	10.7%
>85	0.5%	1.9%	3.2%

*Data and Statistics Bureau, Montana Department of Transportation
#Federal fiscal years end September 30 of the year named.

When the 65 mph national speed limit was rescinded in 1995, the daytime speed limit in Montana reverted to the “basic rule” law, which required vehicles to be driven “...in a careful and prudent manner” but set no specific limit. That provision was declared unconstitutional at the end of 1998. The 1999 Legislature set daytime speeds for cars at 75 mph on Interstates, 70 mph on most other rural highways, and 65 mph at night. These limits became effective as of the end of May 1999. The effect of these limits on fuel consumption was not an issue.

Since the Legislature dealt with speed limits in the 1999 session, it is unlikely to take up this issue again anytime soon. Without national efforts to identify the fuel efficiency of the vehicle fleet at different speeds under real world conditions, any future debates on speed limits are unlikely to consider the effect of speed on fuel use.

Conclusion: Changing highway speed limits probably should not be included as one of the first steps in dealing with greenhouse gas emissions in Montana.

2.5 Transportation alternatives

The amount of fuel used for transportation can be reduced by providing alternatives to private vehicles, especially single-occupant vehicles. The options most discussed nationally, such as light rail or improved fixed-route transit, may not be viable in Montana, but there are alternatives that can work.

2.5.1 Rural transportation management associations

Conventional inter-city bus service continues to wither away in Montana. However, a newer service, aimed at commuters, shows promise for some corridors. Rural transportation management associations (TMA) can provide car pool and van pool programs, along with related services, for small towns near major employment centers.[116]

MDT provided funding to start and maintain the Missoula-Ravalli Transportation Management Association (MR TMA), reputedly the first rural TMA in the country. MR TMA began operations along the congested Highway 93 South corridor in April 1996. At the end of 1998, it had 18 car pools and 2 van pools in operation. The van pool operation will be expanded to 4 vans in 1999, and turned over to the city bus line in Missoula. At present, MR TMA has a waiting list of 165 people seeking to use the vanpool. (Those on the waiting list are referred to carpools.) The annual budget for capital and overhead in 1998 for MR TMA was $135,000. Of that 80 percent comes from MDT and 20 percent comes from public and private local match. The vanpool charges users $0.06 mile to cover operating expenses.

The main justification for TMAs is their contribution to reduction of congestion and associated pollution. A large enough TMA might be sufficient to postpone expanding the capacity of some roads, resulting in substantial savings of public dollars. Even with its modest start, MR TMA is reducing traffic on Highway 93 as it nears Missoula County by 0.5 percent. It also is reducing the demand for parking spaces in Missoula. In the twenty months since its start, MR TMA reduced the number of trips along the corridor by 20,431 and the number of VMT by 645,885. It is projecting a combined (van pool and car pool) reduction of 1,000,000 VMT in 1999. At that rate, MR TMA would reduce CO_2 emissions by nearly 500 tons per year.

MDT has no immediate plans to expand its TMA pilot program; however, MDT staff have identified the Belgrade-Bozeman, Laurel-Billings, and Highway 93 north of Missoula as corridors possibly warranting future consideration for TMAs. Livingston-Bozeman and the areas around Kalispell are other potential locations facing growing congestion.

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[116] Though van pools and car pools can appeal to commuters traveling from one town to another, they are much less likely to attract commuters from the areas of sprawl development immediately around Montana cities. Unlike urban areas in most states, those in Montana are small, which limits the benefits of car pooling. For instance, the Helena Valley would fit within the city limits of Chicago.

Conclusion: There may be opportunities to expand the Montana Department of Transportation's TMA program to other small town-urban center corridors facing near- or medium-term problems with congestion.

2.5.2 Telecommuting

Telecommuting is the substitution of telecommunications for transportation. Workers can telecommute from home or from a local work center close to home. Telecommuting permits workers to eliminate or at least shorten their work trips.

Workers who telecommute find it attractive because it eliminates long commutes and gives them more flexibility in their schedule. Telecommuting is particularly valuable for employees who, for family or health reasons, need to stay close to home. Some employers have found that telecommuting increases productivity and morale.

Arguments against telecommuting focus on the limited amount of driving it can affect. Telecommuting is feasible for only a portion of all workers—primarily information workers—and those that participate will often only eliminate one to three days of commute per week. Some of those who participate may have taken transit or car pools in the past. Errands previously combined with the work trip will still need to be made. Telecommuting may worsen trends toward increased geographic dispersion of residences and work places, which would increase driving distances for non-commute trips. In addition, in Montana, telecommuting has given rise to the "modem cowboy," people who live and work here for out-of-state employers. Some people believe modem cowboys bring more costs than benefits to local communities.

U.S. DOE found that, nationwide, the net benefits of telecommuting are positive, though the countervailing effects of latent demand and increased urban sprawl reduced the potential effect on fuel consumption by 55 percent.[117] Because Montana cities and urban areas are relatively small, and the commutes shorter and less congested, telecommuting may not be as attractive here as elsewhere.

Some businesses in Montana already offer their employees some form of telecommuting, often on an informal or ad hoc basis. Except for concerns about transportation-related pollution, DEQ has not identified a clear and compelling reason why the state should encourage the private sector to pursue telecommuting more than it already is.

State agencies could determine if formal telecommuting programs might be beneficial for them and their employees in terms of morale and productivity. In particular, the state could consider setting up work center offices in small towns near cities with large numbers of state jobs.[118] These centers would have computers, work areas and perhaps 1 or 2 support staff. State agencies could rent a certain number of places in the work center to permanently base staff in the small towns or to accommodate workers who telecommute occasionally. Because costs of the work center would be shared by several agencies, a state agency could afford to decentralize some of its operations. These work centers, while reducing transportation fuel use, might lower agency

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[117] U.S. Department of Energy, Office of Policy, Planning and Program Evaluation. *Energy, Emissions, and Social Consequences of Telecommuting.* Technical Report 1 in series on *Energy Efficiency in the U.S. Economy*, June 1994.

[118] These might include Polson and Hamilton near Missoula, Townsend and Boulder near Helena, Conrad near Great Falls, Three Forks and Livingston near Bozeman, and Columbus and Hardin near Billings.

staff turnover, possibly reduce the amount of office space needed in the city, and provide an economic boost to small towns.

Conclusion: A formal telecommuting program, especially one locating decentralized work centers in small towns, might be attractive to state government.

2.6 Alternative fuels

The final strategy for reducing greenhouse gas emissions from transportation is to switch to alternative fuels, those fuels that are lower in carbon than gasoline and diesel fuel. Montana has some, albeit limited, opportunities to encourage the use of alternative fuels. Montana already has seen the use of compressed natural gas (CNG) liquefied petroleum gas (LPG), ethanol, and bio-diesel. The two fossil fuels have less carbon per unit of energy when compared to gasoline (25 and 12 percent, respectively). Ethanol and biodiesel are made from plant materials; depending on the process employed to make the fuels, their use can release little additional carbon dioxide into the atmosphere.

Natural gas has good potential as an alternative fuel in Montana. Technology for vehicles and refueling infrastructure continues to improve in response to national legislation. Because the vehicles and infrastructure still are more expensive than conventional equipment, the most cost-effective use of natural gas may be in larger vehicles that see lots of service, such as municipal transit fleets or county maintenance fleets. Natural gas fueled vehicles, if properly maintained, can reduce carbon emissions, especially in models that were factory-equipped for natural gas. Aftermarket conversions of cars and light trucks can be more problematic. DEQ knows of almost 400 CNG vehicles in operation in Montana. Several utilities, including Montana Power, EnergyWest, and Montana-Dakota Utilities, use natural gas in some of their vehicles. Malmstrom Air Force Base has more than 50 CNG vehicles and plans obtain additional vehicles. Other CNG vehicles are scattered around the state. Montana currently has 13 refueling stations for CNG.

One area of technological advance that promises a bright future for CNG in Montana and elsewhere is the continuing development of automotive fuel cells.[119] Fuel cells produce electricity without combustion by combining hydrogen and oxygen.[120] The primary waste products from fuel cell operation are heat and water. Fuel cells offer the possibility of substantially reduced emissions of both carbon dioxide and pollutants regulated under the federal Clean Air Act. The development of automotive fuel cells is intertwined with that of stationary fuel cells, which are now commercially available. Though stationary fuel cells are more expensive than conventional heating/electric plants, production costs are expected to decline over the next 5-10 years. The technology for fuel cells in mobile applications is behind that for stationary ones, but is expected to be commercially viable soon. Natural gas, because of its widespread availability, well-developed distribution system and low cost, will likely be an early source of hydrogen for both stationary and mobile fuel cell applications.

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[119] See, for instance, "Fuel cells meet big business." *Economist*, July 24-July 30, 1999, pp.59-61.

[120] A fuel cells website sponsored by an advocacy group has useful background information and links to research centers.

LPG is not attractive for a greenhouse gas program because it offers little reduction in the amount of carbon released and is subject to significant fluctuations in price and availability. In addition, LPG increasingly is imported. Montana has at least 49 LPG refueling stations in the state.[121] A number of route fleets, like Schwan's Fine Foods, and small rural fleet operations have converted to LPG to take advantage of increased vehicle range and lower-than-gasoline prices when they occur. The 1992 Census of Agriculture estimated that over 1,150 vehicles in Montana can be fueled with LPG.[122]

Fuel ethanol is widely used in Montana to increase octane-levels in mid- and premium-grade gasoline and to reduce air pollution. As an octane enhancer, it offers an advantage over other additives, such as MTBE, because it does not pose the same risk for groundwater contamination. A blend of about 8 percent ethanol to 92 percent petroleum gasoline is mandated in Missoula to meet carbon monoxide standards. Since 1997, ethanol blend fuel has voluntarily been used in West Yellowstone during the winter to reduce carbon monoxide and particulates from over-the-snow vehicles used in Yellowstone National Park. Over 7 million gallons of gasoline blended with up to 10 percent ethanol are sold annually in Montana. The use of E-85 (a fuel that is 85 percent ethanol and 15 percent gasoline) is just beginning in Montana, with one public outlet in Helena.[123] Twenty federal vehicles regularly use this fuel, and as of 1999, there are over 520 flex fuel vehicles (FFV) registered in the Montana capable of using any combination of E-85 and gasoline fuel. Because ethanol (and other bio-based products) can be sold in the same manner as a conventional fuel, it offers the advantage of being unnoticed by most consumers when used as a CO reduction strategy.[124]

Ethanol currently is a very expensive way to reduce carbon emissions. For instance, assuming use of ethanol generated zero net carbon dioxide, and ethanol only cost $0.40/gal more than gasoline, the control cost would be at least $164/metric tonne of carbon saved, considerably above that of other strategies.[125] The use of ethanol should be encouraged for air quality reasons, where it excels, with the greenhouse gas emission reductions taken as an additional benefit.

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[121] U.S. DOE maintains website with a list of the locations of stations in the state and nation, as well as a map.

[122] National Agricultural Statistics Service, USDA.

[123] The fuel sells at a price above regular and below premium grade gasoline. Though E-85 does not have as much energy per gallon as gasoline, the increased octane and increased combustion efficiency of E-85 appears to offset the loss in energy content for Montana driving conditions. (Personal conversation, David Poor, GSA Helena Depot manager, with Howard Haines, DEQ, May 1999) Maintenance costs generally are lower with E-85 because ethanol burns cleaner. DEQ plans to work with the private sector and other partners to establish 2 or 3 more refueling stations in the state.

[124] Emissions caused by congestion of snowmobile traffic heading into Yellowstone National Park have been reduced by the use of 8 percent ethanol blend and bio-based lubes. The use of biodiesel and blends in pilot projects in Montana's Yellowstone region is being expanded to county governments and private business. These applications reduce visible soot and odor in tourism-related operations.

[125] This could change in the future. Newer technologies are being introduced in North America that will significantly reduce the cost of fuel ethanol by using waste paper and other sources of ligno-cellulosic feedstocks.

Biodiesel is the ethyl or methyl ester of plant and animal fats and oils.[126] Like ethanol, it is an expensive way to reduce carbon emissions, but may find commercial acceptance as a means to reduce pollution. It could be particularly valuable for two-stroke engines, such as used in snowmobiles and lawnmowers, since there are few technical fixes to clean up those engines. Use of biodiesel could both protect the airshed and reduce operator exposure to hazardous emissions. Biodiesel could have benefits for water quality as well, since natural bacteria are able to break it down more readily than diesel fuel. Much of the biodiesel used in Montana has been from off-spec (non food-grade) canola oil. Interest is developing to use waste oils and grease, such as commercially available used frying oil, to produce biodiesel at a regional facility located near Missoula, Montana. Fuel produced from these feedstocks would save the cost of transporting these wastes to Portland, Oregon, which is current practice. The estimated sale price would be \$1.23 to \$1.75 depending on the size of the plant. A 20 percent blend (or B-20) would range from \$0.72 to \$0.83 per gallon while retaining over half of the emissions reduction benefits.[127]

Montana has not had any regulatory requirements to promote alternative fuel vehicles. Montana is not obligated under the federal Energy Policy Act of 1992 to add alternative fuel vehicles to the state fleet because it did not meet the criteria in the law (a metropolitan area of 250,000 or more in the 1980 census). However the federal fleets within the state are covered by the Act and several of these agencies have alternative fuel vehicles. These include the Postal Service, the USDA, and GSA, and Malmstrom AFB.

The state of Montana is participating with Yellowstone and Teton National Parks, a number of gateway cities and local governments around the parks, Idaho National Environment and Energy Laboratory and private partners in the development of a Clean City Coalition.[128] The Coalition is developing a strategic plan to increase alternative fuel vehicles and infrastructure in the Greater Yellowstone and Grand Teton region. A major focus of the Coalition's effort will be fleets or operations in the recreation/travel industry. By the end of calendar year 1999 the coalition partners plan to be officially designed as a DOE Clean City.

DEQ is starting work on similar projects at Glacier as part of Green Energy Parks Program, a new effort by U.S. DOE. The plans are to investigate the use of biodiesel in the park, and to

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[126] A significant portion of the work to advance the commercialization of biodiesel has been done in, or with the support of, DEQ.

[127] Tom Koehler, Celilo Group. *Draft Proceedings, Alternate Fuels Work Group.* Conference on Transportation Alternatives and Advanced Technology for the 21st Century. National Park Service. Bozeman, June 5, 1999.

[128] The concept of city has been stretched to include the large geographic area surrounding the parks, but this is not the first time. The entire state of West Virginia was one of the first DOE Clean Cities.

improve Glacier's use of CNG vehicles. DEQ is also working with concession owners to plan the use of biodiesel in the marine fleet in Glacier.

Conclusion: DEQ should continue to support the use of bio-based alternative fuels for air quality and pollution prevention purposes.

CHAPTER 3: TRANSPORTATION AND URBAN DESIGN

3.1 *Summary of conclusions*

Where roads and buildings are located, and what kinds of roads and buildings they are, makes up the design of an urban area. Urban design is one of the factors that determine how much transportation fuel people use, even in small cities and towns like we have in Montana. Much of the development of the last few decades can be characterized as "sprawl" development, a form more heavily dependent on vehicle use than traditional, more compact development built before World War II. Changing the design of new investments in roads and buildings could reduce the amount of gasoline and diesel fuel Montanans use. State and local governments have considerable influence over urban design. Montana could act to reduce barriers to the development of less-vehicle dependent urban areas, and to encourage the market to invest in such developments.

While there is rising concern about the impacts of growth, not all those concerns are directly connected to reducing greenhouse gas emissions. More significantly, there is no general agreement on a strategy to control those impacts. Therefore, rather than emphasize comprehensive planning, DEQ focused on the practices and constraints that shape how individuals and organizations make the decisions that, taken together, add up to urban design. Modest actions to encourage Montanans to build more livable communities, ones that don't require as much use of transportation fuel may be what are needed first:

1) State regulations and laws could be reviewed to identify ones that hinder development of compact, mixed-use and pedestrian friendly designs, and alternative standards should be suggested.

2) State agencies could work with lenders, developers and local governments on strategies and technical assistance to promote the merits and techniques of lower cost, less energy-intensive development patterns.

3) Montana could develop new urban highway standards that better balance the trade-offs among the different purposes served by urban highways. Montana also could develop new model standards for local roads that recognize the character of residential neighborhoods and the need to control infrastructure costs.
4) State agencies that already collect data useful for growth planning could develop analytical tools and Web-based data resources to support public and private planning.

3.2 Introduction

Roads and buildings, where they are and what they are, shape the demand for transportation fuel. Build roads and buildings differently, and the demand for fuel will change.[129] This is as true in Bozeman and Augusta as it is in Atlanta and Los Angeles. It may be through their influence on the design of roads and buildings that state and local governments have the most influence on transportation fuel use. Urban design, the shape of our communities, is the sum of countless construction and maintenance investments. These investments determine the feasibility of walking, biking, and shorter vehicle trips. Proper urban design can draw growth from the rural fringes of cities to more central locations by reducing the financial cost and the negative impacts of car use and by supporting those desirable amenities only cities and towns can provide. Building better cities is an alternative to cars in a way that transit, carpooling and the like will never be.

The demand for different types and locations of buildings is not simply the expression of lifestyle preferences or cultural tradition. It is market-driven. Admittedly, this market is more interested in affordability and quality of life than in transportation energy as such. However, it is a market shaped and motivated by government regulation and subsidy, and by private sector financing and insurance requirements. Therefore, it is a market that potentially can be encouraged towards different and less environmentally problematic forms.

Strategies to influence urban design are strategies to influence driving induced by sprawl development in and around cities and towns. Sprawl is an urban phenomenon, yet it includes development in the more or less rural areas adjacent to cities that exist primarily because the city is nearby. Sprawl is not entirely in the eye of the beholder. There are quantifiable indicators of sprawl. For the purposes of analyzing transportation energy, perhaps the most important indicator of sprawl is poor accessibility.[130] With sprawl development, residences may be far from frequently used out-of-home activities or out-of-home activities may be far from each other. Walking as a mode of travel becomes less feasible (as does biking or transit), and the length of trips goes up. Sprawl development, though automobile-oriented, can make vehicular travel more difficult as well.

DEQ has chosen to focus on sprawl development for several reasons. First, sprawl development is an energy-intensive type of development. It requires more transportation energy and it decreases the likelihood of heating buildings using less carbon-intensive technologies and fuels.

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[129] Winston Churchill once observed, "We shape our buildings: thereafter they shape us." (*Time Magazine* Sept. 12, 1960) The same holds true on a grander scale for all our settlement patterns.

[130] Reid Ewing gives a succinct explanation of this and other aspects of sprawl in "Is Los Angeles Style Sprawl Desirable?" *APA Journal*, Winter 1997, p.107-126.

Households in sprawl development, even ones in super-efficient houses, may release more carbon dioxide than do households in inefficient houses in-town.[131] Second, unlike the historic Montana type of development—compact small and medium-sized towns set in a land-based rural economy—sprawl development disregards the economic and climatic realities of our state. Even though the climate may be changing, Montana weather remains harsh, and even though employment in agriculture has dropped, the tourism industry still depends on open land and the traditional towns and cities. Third, promoting or facilitating more compact traditional Montana town development answers some of the rising concerns over growth, about quality of life, safety, affordable housing, time spent on commuting and household errands, and infrastructure costs.

People talking about the problems of growth are talking about urban sprawl, but they're also talking about other issues. Those issues include concern over diminishing open space, proliferating recreation developments in rural areas, and declining small town economies. Dealing with these issues will not necessarily deal with the problem of sprawl. Preserving open space and historical agricultural operations, unless done in a way that encourages or requires compact development in areas adjacent to cities, may simply cause sprawl development to happen in one place instead of another. Thus, protecting open space may do more to influence the starting point of driving than the total amount of driving.[132] Recreation and second home developments are an all or nothing affair, in terms of reducing greenhouse gas emissions. Either they get built or they don't and that determines the level of emissions. There are few techniques for designing roads and other infrastructure necessary for these developments in ways that promote more efficient use of transportation energy. Finally, returning shopping and job opportunities to small towns would indeed reduce the amount of driving in Montana; however reviving small towns is not primarily a problem to be solved by urban design.

In contrast, the impacts of driving—environmental, economic and social—are at the heart of critiques of urban sprawl. DEQ has chosen to focus its analysis on the transportation and design features that constitute sprawl. Strategies that result in denser land use patterns in general, and mixed use patterns in particular, are ones that reduce the need for transportation fuel and that reduce sprawl development. These strategies are consistent with traditional development, with the predominant patterns of urban design found in American towns and cities up to World War

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[131] See, for instance, Rick Browning and Michele Helou. "Impacts of Transportation on Household Energy Use." *Proceedings from the Twenty-second National Passive Solar Conference*, April 1997. Even in Montana, with its cold winters, transportation fuel use can easily account for over one-third of the carbon released by a typical household.

[132] Nevertheless, preserving agricultural land and open space can prevent sprawl if done on the right scale. In at least two Montana counties, agricultural interests have taken the initiative to prevent sprawl by asking their county commissioners to impose agricultural zoning on their area. In southern Jefferson County, 84,000 acres were zoned for agricultural uses in 1995. A similar smaller effort occurred later in Park County southeast of Livingston.

The ordinance adopted by the Jefferson County commission generally prohibits subdividing the land in the zoning district into parcels smaller than 640 acres. The ordinance contains a provision to review the zoning in 6 years. Close to 90 percent of the zoned area is private land; the rest is BLM and state. It's located in the southeast corner of the county, on the lower Boulder River.

The Cooperative Extension Service released a video in 1998 on the agricultural zoning district in Jefferson County, and on other growth issues in Madison, Gallatin and Teton (Idaho) counties. Copies of the 18-minute program "Managing Community Growth" are available for loan through the local extension office.

II.[133] These strategies need to be pursued in ways that increase the attractiveness of urban living. Infrastructure that undercuts urban area amenities becomes one more argument for living outside compact developments.

Finally, urban design can affect space heating energy use within buildings. The orientation of streets influences the amount of solar energy a building receives, which can be substantial even in Montana's cold climate.[134] Second, allowing or encouraging attached building designs will reduce the amount of energy needed for space heating, besides resulting in denser development with lower per unit infrastructure costs and lower transportation energy requirements. Third, more compact development increases the economic feasibility of extending natural gas lines, which allows less carbon-rich natural gas to replace coal-fired electricity.

3.3 Transportation energy used for urban purposes

Estimating the amount of urban driving in the state is necessary to estimate how urban design affects the amount of fuel used. Making such estimates is not straightforward, but driving in urbanized areas appears to use over a third of the transportation fuel consumed in Montana.

The published statistics on urban driving are not adequate for the purpose of this analysis. The Federal Highway Administration (FHWA) publishes annual estimates of the miles traveled by cars and trucks (vehicles miles traveled—VMT) in urban areas, which it defines as incorporated cities of over 5,000 population, plus the most built-up portions of the adjoining areas. There are 14 such cities in Montana.[135] The FHWA definition falls short in smaller states like Montana, where many of the areas considered urban would be country towns elsewhere.[136] Beyond that problem, FHWA doesn't include driving from the sprawl development "doughnut" around each urban core. Most of the people in the doughnut work, shop, go to school and focus their social

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[133] New developments along these lines have been called neo-traditional, new urbanist, or transit-oriented.

[134] A building's heating load can be reduced by facing more windows towards the south. Model results show that a "low mass" building (no basement or slab) in Missoula insulated to the high standards called for in the Model Conservation Standards, and with all of its windows facing south, can be expected to use 15 percent less than a building in which an equal amount of window area faces each of the four cardinal directions. The percentage is higher for houses with slab-on-grade or daylight basements.

Window Orientation	Relative Energy Use
Even	1.00
South	0.85
West	1.06
East	1.06
North	1.23

From an analysis prepared by Larry Palmiter, Ecotope, for the 1983 Northwest Power Planning Council *Power Plan*.

[135] Anaconda, Billings, Bozeman, Butte, Great Falls, Havre, Helena, Kalispell, Laurel, Lewistown, Livingston, Miles City, Missoula and Sidney.

[136] For instance, FHWA does not consider Whitefish, Glendive, Belgrade, Dillon, Polson, Hamilton, or Columbia Falls to be urban areas. However, the FHWA established its definition of "urban" for its own programmatic reasons; the definition does not appear inadequate in that national context.

life on the urban core. They are a part of the town in almost every sense except location. Even if they live on a ranchette, most of their local driving could be defined as being for urban purposes.

DEQ estimated 1997 urban driving in Montana at over 3 billion miles, 32 percent of all VMT driven in Montana. This is 50 percent greater than the FHWA data would suggest.[137] To get this total, DEQ included driving in small towns of 1,000 to 5,000 population. The estimate for those areas was derived from travel data supplied by MDT. DEQ also estimated the amount of driving in the doughnut of sprawl development around the urban areas. Calculation of this was based on professional assessments by city and county planners in the seven largest urban areas in Montana as to what was sprawl development around their towns.[138] The total estimate of 32 percent of state VMT breaks out as: 22 percent of 1997 VMT in Montana occurred in FHWA-defined urban areas, 7 percent in towns of 1,000-5,000 inhabitants, and another 3 percent in driving from houses in the doughnut of sprawl development to the urban core.

Fuel use for urban purposes could be calculated if the efficiency of vehicles, the number of miles per gallon they attained, was known. However, all one can say for certain is that vehicles usually are less efficient in urban driving than in rural driving. Therefore, the percentage of transportation fuel used in Montana for urban driving should be higher than the percentage of state VMT that were in urban areas. Using a reasonable range of assumptions, urban transportation fuel use 1997 was probably 215 million to 230 million gallons of fuel (34 to 37 percent of total fuel use), mostly gasoline. It's important to treat this estimate (and the estimate of urban VMT) as an approximation. Nonetheless, it does give a sense of the amount of fuel use that is influenced by urban design. Whatever savings there are from urban design can only be a fraction of this amount.

3.4 Indications that urban design affects transportation

How a town is built determines how you get around in it. The "need" to drive is a more or less reasonable response to the cost of driving and the nature of our roads and towns and not something intrinsic to our culture or our personal preferences. This can be forgotten when talk turns to how much and what kind of roads going where should be built.

The planning literature is filled with arguments over how and how much urban design affects driving and fuel use.[139] Common sense and professional studies suggest that urban design can

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[137] Nonetheless, even this revised estimate of urban driving is far below the national figure of 60 percent of the total VMT. Montana driving primarily is rural driving.

[138] This estimation of sprawl travel was based on conservative assumptions about residential travel. No estimate was made for commercial traffic in the doughnut area. Travel from small towns that are tied to larger cities, but are far enough away to have an existence of their own, such as Townsend in relation to Helena, or Hamilton in relation to Missoula, was not included. When the result for the seven cities was generalized to the entire state, these conservatisms were assumed to be offset by the likelihood that sprawl development around smaller towns was proportionately less than that around the largest towns.

[139] Ewing gives a long list of references in "Is Los Angeles Style Sprawl Desirable?" *APA Journal*, Winter 1997, p.13. However, these don't represent the entire planning profession. For instance, the Spring 1998 issue of *Access* (University of California Transportation Center) has several articles that question the notion that new urbanism or transit-oriented design significantly affects the amount of driving.

matter.[140] Studies of major urban areas in the U.S. and around the world show substantial differences for fuel used per capita, a difference that in part must be due to the different urban designs, including different transportation systems.[141] Even in the U.S., the average VMT per household varies by as much as 13 percent among different regions of the country.[142]

The exact difference that urban design makes probably depends on the city and the neighborhood. Accessibility to regional as well as local destinations affects the amount of driving done by households.[143] Holtzclaw estimates that doubling urban density results in a 25-30 percent reduction in VMT.[144] The LUTRAQ (Land Use, Transportation, Air Quality) project in Portland, Oregon, found that household VMT and the number of vehicle trips dropped (by about one-half and one-quarter, respectively) as the quality of the pedestrian infrastructure improved.[145] The number of trips made by walking more than doubled once density increased to 4-5 households per acre. This is a level of density common in the older parts of Montana towns, such as the University district in Missoula and the upper west side of Helena. Other, but not all, studies of neighborhoods have found similar differences in vehicle use, depending on urban design.

Another line of inquiry about the effect of design on driving looks at induced transportation, driving that happens only because a road is built or expanded. While traffic tends to increase as population grows and economic activity expands, the amount of increase is influenced by the "cost" of driving. Improving roads makes it easier or quicker to get from one place to another. Trips that previously weren't worth it now are.[146] Said another way, new roads, by reducing the

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[140] Logically, there are three possible relations between urban design and fuel use: 1) low-density sprawl development requires less fuel use than does compact development, 2) today's mix of compact and sprawl development best minimizes fuel use, or 3) some more compact form, either along traditional lines or otherwise, would reduce the amount of fuel used. The first point seems implausible, while the second implies that this is the best of all possible worlds, which likewise seems doubtful.

[141] P.W.G. Newman and J.R. Kenworthy. "Gasoline Consumption and Cities: A Comparison of U.S. Cities with a Global Survey," *Journal of American Planning Association.* Vol.55, 1989, pp.24-37. The differences could be explained as cultural, but that explanation quickly becomes circular and ridiculous. You can say that Houston has a much higher fuel use per capita than Boston because the cultures are different, but then you have to say that Detroit and Denver, which have about the same rate of fuel use, have similar cultures. A simpler explanation is that the type and amount of driving the inhabitants have to do is different.

[142] Energy Information Administration. *Household Vehicles Energy Consumption 1994.* P.47.

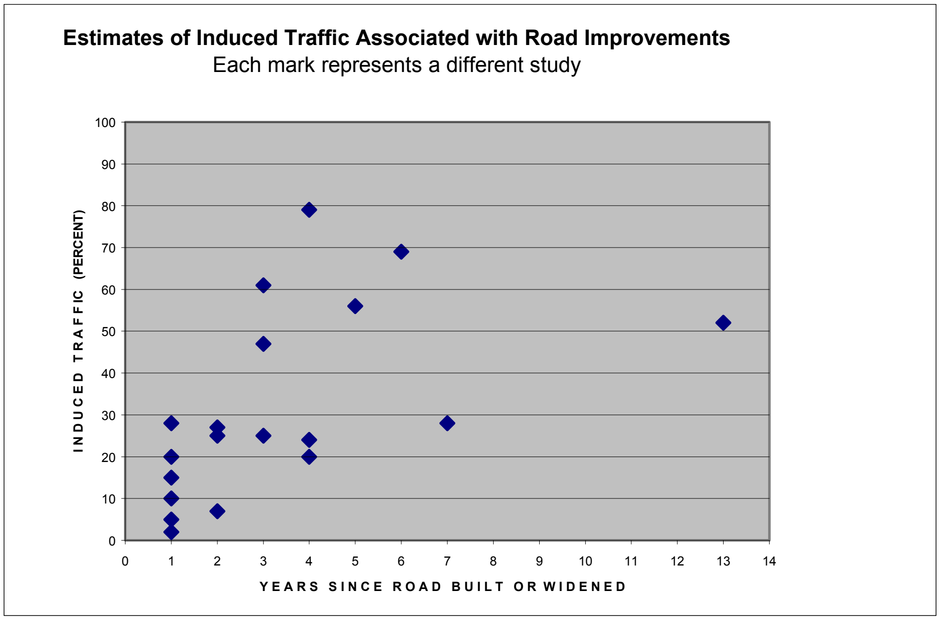
[143] Possibly because they were built at the edge of urban areas, some of the new "neo-traditional" designs that pattern themselves after older styles of urban design have not lived up fully to their promise of reducing the amount of household driving.

[144] John Holtzclaw. *Using Residential Patterns and Transit to Decrease Auto Dependence and Costs*. San Francisco, CA: Natural Resources Defense Council 1994.

[145] 1000 Friends of Oregon. *The Pedestrian Environment, Vol. 4A*, December 1993. The LUTRAQ findings influenced the Oregon Department of Transportation's decision to cancel a proposed by-pass on the west side of Portland in favor of a new transit line and other minor improvements. (1000 Friends of Oregon, *The Pedestrian Environment, Vol. 4A*, December 1993.)

[146] This observation also is basic economics. Some engineers remain uncomfortable with the notion that roads create traffic, but they have been unable to explain why driving a car should be different from all other activities, for which costs do matter.

cost in time and inconvenience, encourage the least valued trips. However, one has to remember that new roads won't cause travel that has zero value.[147] There are no Montana-specific studies of induced travel, and the engineering profession does not agree on the extent to which new roads induce traffic. Studies of major road projects report levels of induced travel ranging from 0 to 30 percent increase one year after expansion and from 20 to 80 percent four years after the project was opened (see graph).[148] For the purposes of this plan, it's sufficient to know that improved roads are one of the causes of increased driving. Roads can be designed and located in ways that increase or decrease the amount of traffic.[149]



From: Mark Hansen. "Do New Highways Generate Traffic?" *Access*, No. 7, Fall 1995

There are some Montana examples of the relation between settlement patterns and driving. First, Montanans actually use walking as a means of getting to work more than most Americans. According to the 1990 Census, 7.7 percent of Montanans walked to work, about double the national average. This propensity to walk was not spread evenly across the state. The largest numbers of walkers, and many of the highest percentages, were found in the older sections of cities, neighborhoods with designs that were more traditional and less vehicle-oriented (see maps of Billings and Missoula).[150]

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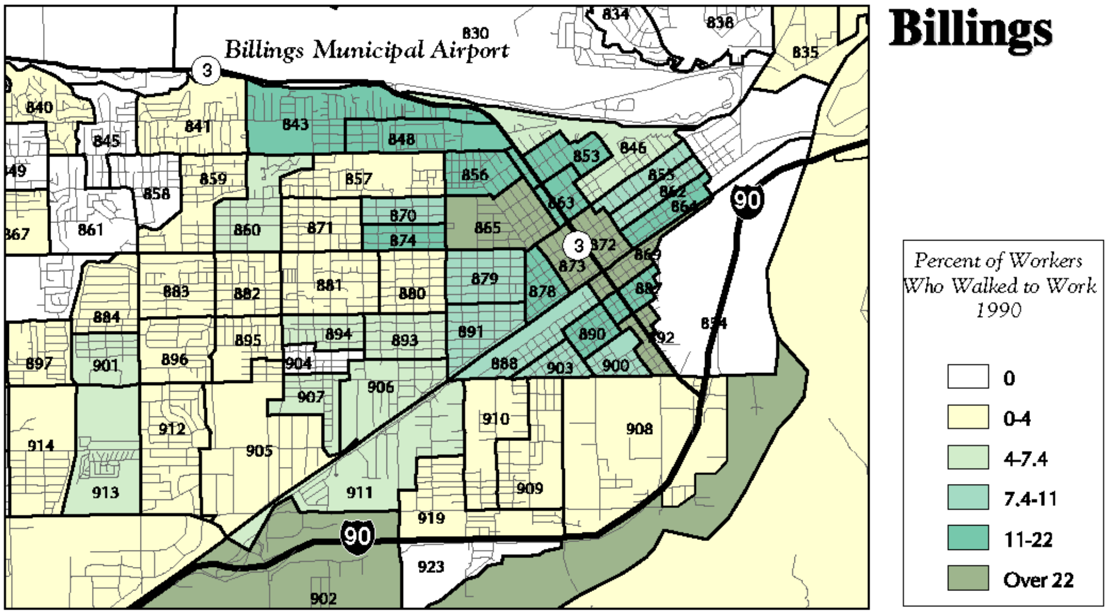
[147] Building the Interstates lowered the cost of travel dramatically, but I-15 north of Conrad and I-94 east of Miles City still average 3,000 cars or less per day, decades after they were built.

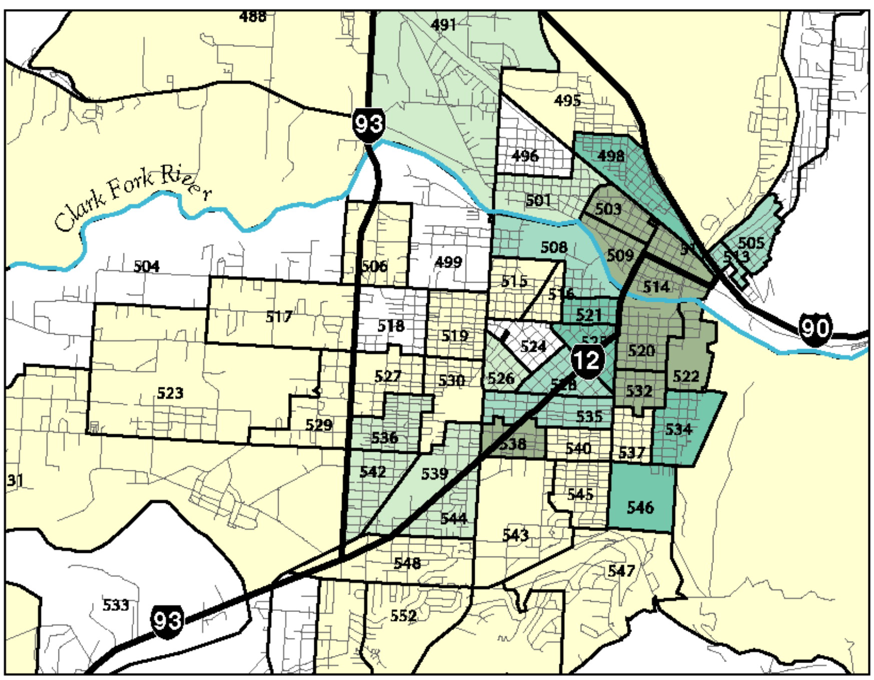
[148] Mark Hansen. "Do New Highways Generate Traffic?" *Access*, No. 7, Fall 1995, pp. 16-22. A more technical report on the findings appears in: Mark Hansen and Yuanlin Huang. "Road Supply and Traffic in California Urban Areas." *Transportation Research—Part A, Policy and Practice*. Pergamon Press, Great Britain. Vol.3. No. 3, pp.205-218, 1997.

[149] A brief bibliography on induced traffic may be found in the Appendix on p.68.

[150] Walking is concentrated in areas where residences are close to work locations. However, these data aren't adequate to identify specific design features that encourage walking. For that, more work such as done in the LUTRAQ series of studies is necessary.

PERCENT OF WORKERS WHO WALKED TO WORK

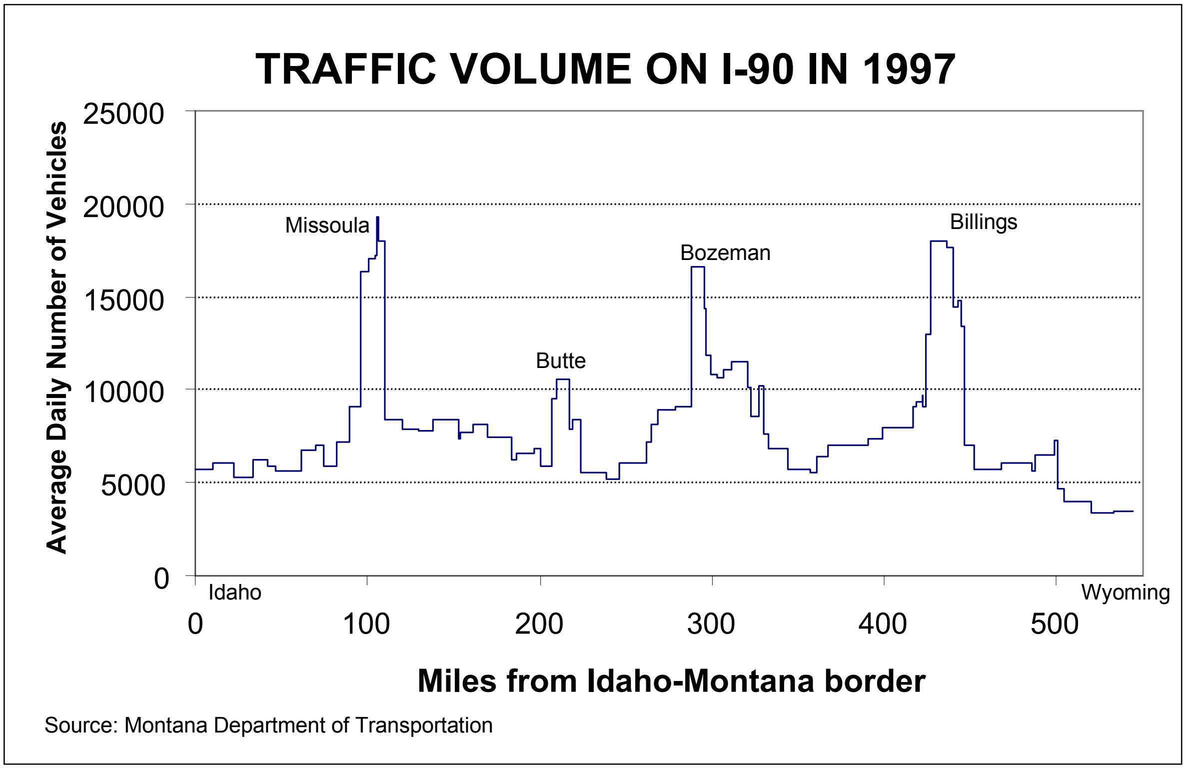


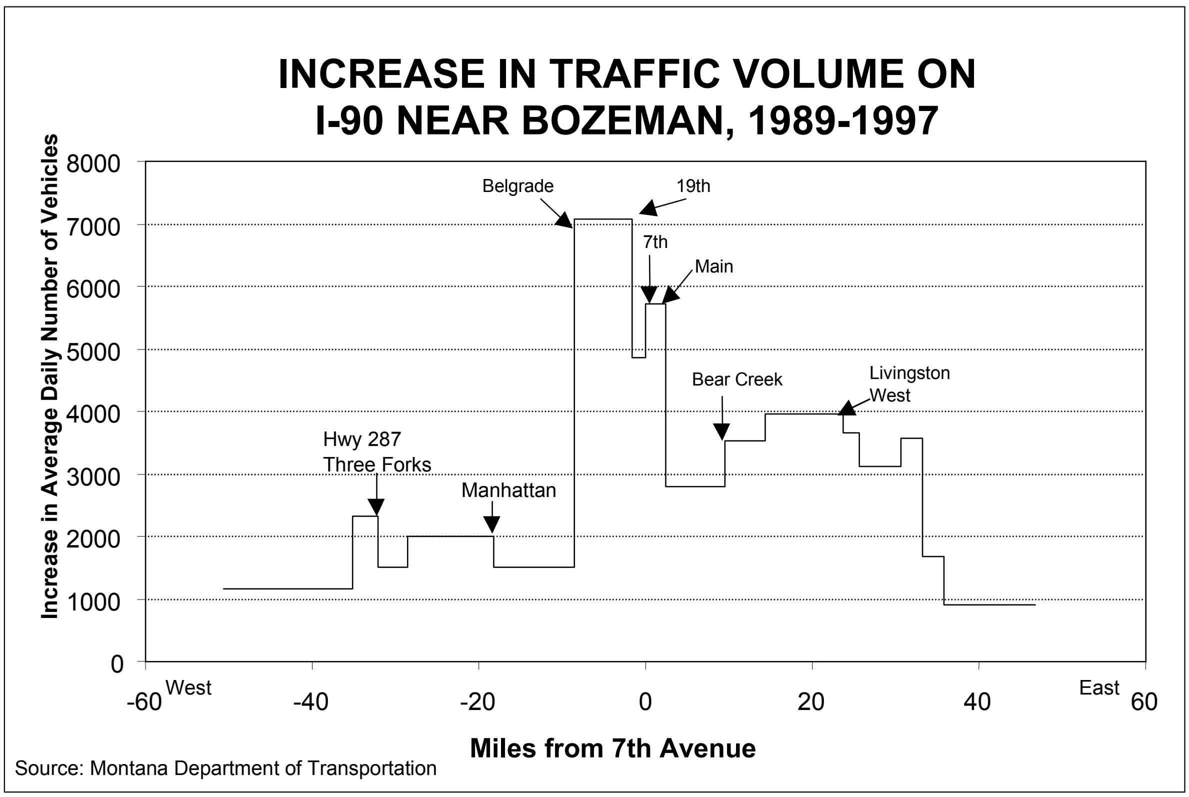


Each census block is labled with an ID number that can be used to find the statistics for that block.

Source: U.S. Census

Second, traffic on the Interstates is greater around the major cities, showing how their influence extends far beyond their boundaries (see I-90 graph). Over time, traffic on the Interstates has increased in response to shifts in where housing is being built. Perhaps the most dramatic instance of this is in the Bozeman area (see Bozeman graph). Between 1989 and 1997, traffic between Belgrade and Bozeman, which are 9 miles apart, increased by over 7,000 to almost


TRAFFIC VOLUME ON I-90 IN 1997
Average Daily Number of Vehicles
25000
20000
15000
10000
5000
0
Missoula
Butte
Bozeman
Billings
Idaho
Wyoming
0
100
200
300
400
500
Miles from Idaho-Montana border
Source: Montana Department of Transportation


INCREASE IN TRAFFIC VOLUME ON
I-90 NEAR BOZEMAN, 1989-1997
Increase in Average Daily Number of Vehicles
8000
7000
6000
5000
4000
3000
2000
1000
0
Belgrade
19th
7th
Main
Bear Creek
Livingston
West
Hwy 287
Three Forks
Manhattan
-60
West
-40
-20
0
20
40
East
60
Miles from 7th Avenue
Source: Montana Department of Transportation

17,000 vehicles per day.[151] During this time, most of the jobs and the shopping in the area stayed in Bozeman, but housing development spread out. The pattern of urban growth dramatically increased vehicle traffic.

Third, Missoula tested an alternative urban development scenario as part of preparing its 1996 transportation plan. The plan was based on a transportation model that predicted traffic volumes, given a forecast of future growth in the population and the economy. Under the alternative scenario (Test Run #6), the daily number of vehicle miles traveled in 2015 was 6.5 percent less than with the business as usual scenario. What is particularly striking is how modest the differences were between the current business as usual scenario and the alternative scenario, which followed urban designs more like the pre-World War II areas of town. For the alternative scenario, Missoula planners assumed growth would make best use of available urban services, such as sewer and water, would include in-fill development in existing areas, that development at the edges would be less sprawling, and that significant pedestrian and bike facility improvements would be made. The alternative scenario did not assume extremely high densities; rather it used densities such as found in the University district or the lower Rattlesnake (about 4 units, plus roads, alleys and so forth, per acre). This modest scenario suggests that significant reductions in vehicle use are possible simply by building an updated version of the older portions of Montana cities.

3.5 Why urban design matters

Urban design matters for energy use, but it also matters for other and possibly more compelling reasons. These include equity, local government budgets, air quality and economic development.[152]

First, one-third of Montanans can't drive. A large portion of the remainder spend much of their day hauling that one-third around.[153] Most of those who can't drive are under 16, but a growing number of non-drivers or reluctant drivers are elderly Montanans. By building cities and towns that are relentlessly auto-oriented, we strip away the independence of a large part of our population. Obviously not all of our social problems are caused by this isolation, but one can safely assume that some of them are.

Second, auto-dependent sprawl development costs public resources. Denser, mixed-use development is cheaper than current suburban development. A recently completed study of growth in the Salt Lake City area shows just how dramatic that difference can be. The study, prepared under the direction of the Governor's Office of Planning and Budget, found that by 2020 business as usual would have a 70 percent greater cost in water, sewer, transportation, and utilities infrastructure than more compact development. The business as usual scenario would

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[151] Traffic from Livingston, 26 miles east and clearly more than a bedroom suburb of Bozeman, also increased, by 3,000 vehicle trips per day, to 11,000 vpd.

[152] An overview of the issues of growth and links to related sites can be found at EPA's Smart Growth Network site.

[153] At the end of spring soccer season in 1999, the Surface Transportation Policy Project released a report titled High Mileage Moms that concluded, "Women have become the bus drivers of the 1990s."

lead to 27 percent more water use in the region.[154] A study of Loudoun County, Virginia found that net public costs were about $2,200 per dwelling where the density was one unit per five acres, compared to $700 per dwelling where the density was 4.5 units per acre.[155] This reflects the fact that low-density subdivisions require public services that are similar on a per capita basis to those required by higher-density areas, but convert much more land into development. Other studies have consistently found that increasing density reduces per dwelling unit infrastructure costs. Often, the costs for this sprawl development are borne by existing, more compact development.

There are other down sides to sprawl development. Emergency response can be far worse. A study of Chicago-area developments found that police response times were as much as 600 percent longer, on average, in low density sprawl development, ambulance response times were as much as 50 percent longer, and fire response times were as much as 33 percent longer.[156] Sprawl development also can increase the amount of energy needed to supply other utilities, especially water and sewer. With more impervious areas—more roads, parking lots and roof area—per capita, sprawl development causes greater runoff and greater damage to surface water.

Third, urban design affects the amount of carbon monoxide, particulates, and other pollutants put into the air by vehicles. The connection between road design and air quality already is recognized by the federal Clean Air Act through the requirement that highway investments conform to the intent of the act. Recent research in California suggests that the models of vehicle emissions used to assess conformity underestimate the amount of pollution released at higher, less congested speeds and over-estimate the amounts released at slower speeds.[157] If this conclusion is incorporated into federal regulations, sprawl development could have a harder time, and traditional compact development an easier time, complying with the Clean Air Act.

Finally, there's some evidence that building too many roads is bad for the economy. A study for the World Bank found that after a certain point the diseconomies associated with increasing car use and low density suburban sprawl drain cities of wealth compared to cities with more balanced transport systems and less dispersed urban land use.[158] This is not unexpected, since

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[154] The modeling was done for Envision Utah, a public-private partnership to develop a broadly supported growth strategy.

[155] Brabec, E. "The Economics of Preserving Open Space," *Rural by Design: Maintaining Small Town Character.* Chicago: American Planning Association. 1994. P.283.

[156] A. Ann Sorensen and J. Dixon Esseks. *Living on the Edge: The Costs and Risks of Scatter Development*. Center for Agriculture in the Environment, Northern Illinois University, DeKalb, Illinois. March 1998.

[157] Studies by Dr. Matthew Barth of the Center for Environmental Research and Technology, UC Riverside, suggest that moderate congestion results in lower emissions than free-flowing highways. Drivers in traffic moving at what models have assumed to be steady speeds actually maintain their place in the flow by constantly depressing and letting up on the accelerator pedal ("dithering"), which raises the emissions. Pumping the pedal causes the fuel-air mix to be alternatively rich and lean, increasing emissions. Dithering raises emissions at any speed, but especially at high speed. (Matthew Barth, George Scora, and Theodore Younglove. "Estimating Emissions and Fuel Consumption for Different Levels of Freeway Congestion." Presented at the 78th Annual Transportation Research Board Meeting, Washington DC, January 1999.)

[158] Jeff Kenworthy, Felix Laube, Peter Newman and Paul Barter. *Indicators of Transport Efficiency in 37 Global Cities*. February 1997. Available from ISTP Publications.

adding roads in a mature transportation network obviously lowers the cost of doing business less than adding a road in a network where links are scarce. The World Bank finding is consistent with the studies reported in the previous chapter (p.1) showing that new roads redirect economic growth rather than create additional growth.

3.6 What to do now

It's one thing to know that urban design shapes demand for travel but another thing to know how to build the next development or the next road in ways that reduce travel demand. Any individual project is a small portion of the entire urban fabric. How it affects transportation demand will change over time as the city around it changes. In general, one should build projects that have both more households per acre than conventional practice and a mix of development that has both housing and travel destinations (jobs, shopping and entertainment).[159] Increasing the amount of commercial development within easy walking distance also decreases the lengths of trips for those who must drive. Development should be done in ways that generally don't discourage walking, biking, or shorter vehicle trips. Further, these projects should be built in ways that don't increase the disincentives to urban living, annoyances like noise and crowding.[160] Developments that achieve these goals don't have to be up-scale or exotic. An example is Kagy Korner in Bozeman, with a daycare, pizza place, video rental, and convenience store right on the edge of a neighborhood; it may not dramatically change the amount of driving, but it makes a difference.

Growth, sprawl development and loss of open space clearly are concerns in Montana, especially in the faster growing valleys in the western part of the state. However, unlike in some other states, public opinion in Montana has not coalesced around any potential solution(s). Oregon supports urban growth boundaries. Maryland has "Smart Growth" policies propelled largely by targeted public investment. Montana has nothing similar to these ideas being seriously and widely promoted as public policy, inside or outside government. This was made clear when the Legislature's Environmental Quality Council (EQC), after its 1997-1998 study of the question of growth, was unable to recommend any new tool for responding to growth.[161]

Montana counties, especially the more populous ones, do make serious efforts at comprehensive planning, but with mixed results. County commissioners everywhere are accused of ignoring key provisions of their county's plan. The planning process itself ranges from the dramatic—serious threats of violence against the planners during the failed Flathead County effort in the mid-1990s—to the more mundane—the Lewis and Clark County plan update that has been underway for two and a half years and counting. Sincere efforts to involve the entire

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[159] The number of households per acre—the density—in the older, traditional parts of Montana towns isn't all that high in the national context. For instance, the highest density areas of Missoula, near the downtown, have 8 units per acre.

[160] Crowding is not the same as density. Density is the number of something per unit area; crowding is the result of too many people or vehicles trying to use the same space at the same time.

[161] There was agreement that too many planning decisions were being made in subdivision reviews and not enough in actual plans by local government. Legislation to change laws relating to local planning and subdivision review was proposed and passed as SB97 (see p.66).

community, such as made in the preparation of these two plans, are no guarantee that a consensus on growth will be reached.

Given the challenges facing existing planning efforts, DEQ is not ready to identify specific comprehensive practices and plans to influence transportation patterns through urban design. Instead, DEQ supports an initial two-pronged strategy to reduce the environmental and financial cost of development. Montana should 1) improve the information and analytical tools used for decision making on urban design, both in regulatory and market arenas, and 2) reduce regulatory constraints to designs that lower the need to drive. This general approach is based on the one receiving wide support during the EQC study of planning for growth.

Providing information and modifying regulations is a modest beginning to changing urban design. However, the sprawling development patterns we see today are not the result of the market at work but are, in significant respects, results of market intervention by government or of market failure.[162] Subsidies for the automobile encourage driving.[163] Local land use regulations discourage higher densities and mixed use developments even where market forces would create them. The costs and consequences of different infrastructure designs, if better known and—more importantly—better allocated, would change people's willingness to build one way as opposed to another.[164]

3.6.1 Review existing state codes and regulations

Montana has laws, regulations and codes that hinder construction of compact mixed-use development and lower-cost infrastructure. Some of these legal requirements have merits that

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[162] Markets can fail to deliver optimal results when, for instance, the price of a good is obscured (as is the case with public roads) or when the good is a public one, with a value but no price (as is the case with clean air).

[163] Subsidies for driving also can raise the price of living in town. As discussed in the previous chapter (p.32), local roads in the large urban areas generate more fuel taxes than are returned to them. Property taxes on the people in live in town have to be raised to make up the difference. In effect, city dwellers pay to make other housing locations look cheaper.

In addition to those local subsidies, Montana receives back over $2 for every $1 paid in federal fuel taxes in Montana. To some extent, this is justifiable because roads through Montana are part of a national network and serve as a bridge between more populous areas. Even though non-resident drivers receive a greater subsidy (since more of their driving is on roads eligible for highway funds) than do Montanans, Montana settlement patterns obviously are different from what they would have been had Montanans had to finance their own transportation system.

Some analysts identify other subsidies, such as "free" parking (paid indirectly in higher costs of goods and services, or lower employee pay), tax incentives that encourage new construction, and external impacts such as tailpipe emissions, noise, and the creation of barriers to non-motorized travel, for which vehicles pay little or none of the cost. (An interesting article on tax policy and urban design is one by Thomas Hanchett. "U.S. Tax Policy and the Shopping-Center Boom of the 1950s and 1960s." *American Historical Review.* Vol. 101, No. 4, October 1996. pp.1082-1110.)

[164] Actions other than those recommended here probably would have more sweeping effect. Reducing the cost to consumers of city water and sewer, revising Montana's laws on annexation to give greater weight to the benefits of rational patterns of growth and infrastructure development, and changing local tax rates to better reflect the cost of providing services to areas of different density are just some ways to encourage more compact development. Taking these actions could be difficult and controversial; they probably are not attractive first steps in dealing with sprawl. (This discussion based on a memo from Dave Cole, Department of Commerce, to Paul Cartwright, DEQ, September 28, 1999, and subsequent conversations with the Community Development Bureau.)

override their effect on urban design, some don't. Examples of these problems were identified by EQC in the course of its study on growth-related issues. Some requirements reflect the standards of one profession without considering the implications for other aspects of the situation. For instance, the City of Helena requires 2 off-street parking spaces for every residence, even though half the households in town own 1 or no cars. Some requirements protect one aspect of health without considering other public needs. Montana water quality regulations generally require a minimum of 1-acre lot size for a septic tank, but don't consider cumulative impact on an aquifer. The result is a ring of low density housing, difficult to redevelop, around every town and no guarantee of environmental protection in the long run. Finally, not all the model codes local relied upon by governments recognize changes in professional practices that could support compact development along traditional lines. For instance, commercial and even some industrial development can be designed to be much less intrusive on their neighbors than was the case when zoning codes originated.

Conclusion: DEQ should identify any of its standards that hinder development of compact, mixed-use and pedestrian friendly designs and suggest alternative standards where possible. Other relevant agencies could take similar steps.

3.6.2 Educate lenders and government regulators on best design practices

Montana developers and lenders do not necessarily feel comfortable building or financing design practices that require less transportation energy. While developers around the country are making money building such developments, even ones that are fully neo-traditional in design,[165] very few developers in Montana are even willing to consider such designs. Possibly because of the small size of the Montana market, lenders and government regulators are less willing to take risks on developments perceived as out of the ordinary. However, as the continued high price for houses in the older parts of towns shows, some portion of the market wants urban design that doesn't follow current conventions, even when it comes with houses that are in less than perfect repair.

Increasing lenders' and government officials' understanding of design practices that reduce transportation costs while enhancing livability will make them more likely to receive financial and regulatory backing. Seminars tailored for these audiences, a best practices guidebook such as Florida prepared,[166] and documentation of traditional design practices that already exist and work in Montana would be useful.

Besides reducing transportation energy, best practices have other environmental benefits, especially with water quality. Density can be increased in a way that reduces storm runoff and increases feasibility of city sewer service. As an extreme example, a design proposed for a suburb of Vancouver, B.C., has over 17 units per acre, more than 4 times the conventional density, yet approximately the same amount of impervious surface.[167]

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[165] "New urbanist projects attract investment." *New Urban News.* Vol.4, No.1. January-February 1999. P.1.

[166] Reid Ewing. *Best Development Practices: Doing the Right Thing and Making Money at the Same Time*. Florida Department of Community Affairs, 1996. Now available through the American Planning Association.

[167] Fraser Valley Real Estate Board. *Alternative Development Standards for Sustainable Communities*. April 1998.

Conclusion: DEQ, in cooperation with the Department of Commerce, local governments, lenders and the development community, should devise strategies and technical assistance to promote the merits and techniques of lower cost, less energy-intensive, and less-polluting development patterns, especially ones that minimize the impacts of transportation.

3.6.3 Develop new urban highway and local road design standards and practices

While streets move vehicular traffic, they also move pedestrians and bicyclists. They are public places for people to meet and see each other. They can connect neighborhoods in the city, or serve as barriers to those connections. They set the look and feel of a town. Professional road design standards and practices have only recently started to recognize and accommodate the full range of functions of streets in urban areas.

Inappropriate street design increases greenhouse gas emissions in two ways. First, it can undercut the viability of walking and biking. Second, it increases the cost and decreases the quality of life in towns, encouraging people to move out of town, where they are more dependent on driving. State design standards for major roads in towns, and local standards for smaller roads, have been accused of undermining the livability of our towns and the viability of travel by any means but cars. Some people are questioning why highways through major towns are designed first and foremost to accommodate through traffic, when that is only a few percent of the vehicles on the road.[168] Others are questioning the costs and safety risks of building roads in residential neighborhoods to widths greater than most rural highways.[169] In defense of highway engineers, their mission generally has been stated in terms that equate to moving more cars faster.

Sometimes moving more cars faster has been confused with guaranteeing safety, but this isn't necessarily so. A look at the different designs defended by highway engineers in different parts of the country, or in other countries, shows there are many ways to build safe roads. Engineers in Portland, Oregon and Boulder, Colorado, design residential roads that are 26 feet wide, with parking on both sides; Helena and Bozeman engineers adamantly maintain these are unsafe.[170] Firemen in Australia have no problem with streets that are even narrower; American fire standards imply safety is impossible with less than 36-foot streets. If there's only one way to accommodate cars safely, then most engineers must be wrong. If, however, most engineers are right, then road standards must be based in part on non-engineering considerations of what the public wants or is believed to need.

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[168] For instance, of the traffic on Highway 12 through Helena, it's likely that 5 percent or less is through traffic; the rest is either local traffic or vehicles with destinations in Helena.

[169] Engineers are discussing the relation of street width and speed, and street width and accidents, especially on residential streets. Wider streets apparently encourage higher speeds than are appropriate for the surrounding land uses and are associated with higher rates of accidents. See, for instance: Christopher Poe and John Mason. "Geometric Design Guidelines to Achieve Desired Operating Speed on Urban Streets." *Proceedings, Institute of Transportation Engineers 65th Annual Meeting, 1995 Compendium of Technical Papers*, and Peter Swift, Dan Painter, and Mathew Goldstein. *Residential Street Typology and Injury Accident Frequency.* City of Longmont, Colorado. 1997.

[170] Boulder 26-foot wide streets are limited to 350 feet in length, and must intersect with streets that are wider.

Montana could develop road standards that facilitate the choice of alternatives to driving and that enhance the attractiveness of living in urban as opposed to sprawl areas. Other state transportation departments already are doing this for major roads in their jurisdictions. The Vermont Agency of Transportation developed standards that help preserve Vermont's historic look and feel. The Oregon Department of Transportation is completely rewriting the *ODOT Highway Design Manual*, and will incorporate a much more thorough section on urban design, including greater sensitivity to the land use environment through which a highway passes. ODOT also is preparing a "Main Street Handbook," written more for city officials and other laymen, on the problem of balancing highway through-traffic and the commercial and pedestrian activities found along most main streets.

Towns across the country, including western towns in snow country, like Boulder, Colorado, have developed new street standards that reduce residential street width requirements. They have done so partly to improve safety by controlling the amount and speed of traffic in residential neighborhoods; but also to reduce the cost of new houses, a cost that always includes the new roads built in the neighborhood. This movement is sufficiently accepted that the Institute of Transportation Engineers, one of the major standard setting organizations for transportation infrastructure, has developed guidelines for these kinds of projects.[171]

Conclusion: There are urban highway standards that best balance the trade-offs between the different functions a highway serves. Likewise, there are standards for local roads that recognize the character of residential neighborhoods and the need to control infrastructure costs. Any of these standards that are appropriate for Montana conditions could be adopted.

3.6.4 Develop more comprehensive tools for evaluating the impact of new developments

In 1999, the Legislature passed SB97, which changed planning requirements for local governments that have a growth policy.[172] Because the law reduces the hearings requirements on subdividing land, it's likely that developers will be pushing local governments to develop growth policies, to do comprehensive planning and to develop the supporting zoning ordinances. The planning offices of most local governments lack the time and resources to do the kind of analyses that the problems of growth in Montana demand. Since SB97 did not set detailed standards for assessing the adequacy of a growth policy, perfunctory efforts and policies that are challenged in court are a real possibility.

State government could improve local government planning efforts by providing analytical tools and data packaged for easy analysis. Computer programs, such as SmartPlaces (now being tested in Bozeman, through a DEQ grant) and government accounting procedures that better track the costs of serving different areas would give local officials greater understanding of the developments they are being asked to approve. GIS-based data sets, such as the property ("cadastral") information of the Department of Administration and the road databases under development by MDT, could be made available on the Web in a form that would facilitate

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[171] Institute of Transportation Engineers. *Traditional Neighborhood Development: Street Design Guidelines*. 1997.

[172] Local governments are not required to have a planning board, but any unit that does must develop a growth policy. Prior to SB97, "growth policies" were called "master plans."

analyzing different development plans. Many of the data that would be useful to local governments come from data sets containing sensitive or confidential information. Rather than allow direct access to these data sets, the state could build a data clearinghouse around growth policy, with sensitive, proprietary and irrelevant data excluded. DEQ, Department of Administration, Department of Revenue, Montana Department of Transportation, Department of Fish, Wildlife and Parks and Department of Commerce all have data that would be useful to local governments. All these agencies, to support their own missions, could encourage sound planning by local governments. (These same data would be useful to private developers. They could help the developers identify potential problems before substantial commitments had been made to some project.)

A large number of GIS projects already is underway in state and federal agencies and in several counties, with a great deal of effort being expended to make the data more generally available and available in interchangeable formats. Work to establish a growth planning data clearinghouse or to otherwise make those GIS resources available could be coordinated with the Montana Geographic Information Council (MGIC), a policy level council with broad representation created by executive order of the Governor. At the technical level, work should be coordinated with the Technical Working Group (TWG) and the Montana Local Government GIS Coalition (MLGGC).

Conclusion: Montana could continue and expand development and deployment of analytical tools and Web-based data resources to support local growth planning efforts.

3.7 Appendix: Induced traffic

The need to assess whether new construction can decrease congestion and to properly identify the benefits of that construction has prompted research on "induced traffic," traffic generated because a road became available to carry that traffic. The traffic engineering profession could well develop a better understanding of induced traffic in the next few years. For instance, the newest version of the USDOT Highway Economic Requirements System (HERS) investment analysis model uses a travel demand elasticity factor of -0.8 for the short term, and -1.0 for the long term, meaning that if users' generalized costs (travel time and vehicle expenses) decrease by 10 percent, travel is predicted to increase 8 percent within 5 years, and an additional 2 percent within 20 years. The question of induced demand is likely to influence construction decisions (and therefore amounts of driving) in the future. The following bibliography provides some references on induced traffic.

Mark Hansen and Yuanlin Huang, "Road Supply and Traffic in California Urban Areas," *Transportation Research A*, Vol. 31, No. 3, 1997, pp. 205-218.

Standing Advisory Committee on Trunk Road Assessment, *Trunk Roads and the Generation of Traffic*, UKDoT, HMSO (London), 1994.

Phil Goodwin, "Empirical Evidence on Induced Traffic," *Transportation*, Vol.23, No. 1, Feb. 1996, pp. 35-54. This special issue of the journal *Transportation* is devoted to induced travel.

Robert B. Noland. Relationships Between Highway Capacity And Induced Vehicle Travel. U.S. EPA revised: June 28, 1999. presented at the 78th Annual Meeting of the Transportation Research Board, Jan. 1999 (paper no. 991069).

Harry Cohen, "Review of Empirical Studies of Induced Traffic," *Expanding Metropolitan Highways: Implications for Air Quality and Energy Use*, Transportation Research Board, Special Report #345, National Academy Press (Washington DC), 1995, Appendix B, pp. 295-309.

Social Costs of Alternative Land Development Scenarios Federal Highway Administration website. 1998

Todd Litman's "Traffic Calming: Implications for Transport Planning" cites and summarizes a number of studies on generated/induced travel. This and other studies that deal with induced transportation and related issues are available from Victoria Transport Policy Institute. Victoria, B.C. Canada.

Cairns, Hass-Klau and Goodwin, Traffic Impacts of Highway Capacity Reductions: Assessment of the Evidence, London Transport Planning. London, 1998.

CHAPTER 4: ELECTRIC UTILITY INDUSTRY AND ELECTRICITY USE

4.1 Introduction

The electric utility industry is a major emitter of greenhouse gases. Nationwide, electric generating plants contribute 30 percent of total greenhouse gas emissions. Almost 90 percent of those emissions come from coal-fired plants. Reducing emissions from the utility sector essentially means reducing emissions from coal use.[173]

In Montana, electricity consumption accounted for almost one-quarter of the inventoried emissions in 1990. Electricity generation actually produces 40 percent of the greenhouse gas emissions, but for purposes of accounting for emissions nationwide, EPA charges a portion of these generating emissions against the states that receive electricity exported from Montana.[174]

The utility industry is an obvious priority for efforts to control greenhouse gases. The sheer amount of greenhouse gas emissions from electricity generation means even small improvements in generation or end-use efficiency produce substantial reductions in emissions. Administering a greenhouse gas program may be easier in the electric industry than in most industries. The 2,060 MW coal-fired generating complex at Colstrip is by far the largest identifiable individual source of greenhouse gases in Montana. Emissions from Colstrip, along with those of smaller plants at Billings, Sydney, Glendive and Miles City, are easily trackable. The utility industry has been regulated for most of this century, and has been subject to a variety of environmental regulations. It has developed internal mechanisms to account for environmental impacts in decision making.

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[173] US Energy Information Administration. Emissions of Greenhouse Gases in the United States, 1997. Generating plants also are major sources of pollutants regulated under the federal Clean Air Act. The 1996 air emissions from the 100 largest generating companies can be found in *Benchmarking Air Emissions of Electric Utility Generators in the United States*, a report issued in 1998 by Natural Resources Defense Council and Public Service Electric and Gas Company. None of the Montana generating plants is currently causing a violation of national air quality standards.

[174] A description of the utility industry in Montana may be found in the State Electricity Profile prepared by US Energy Information Administration.

The obvious approach of starting with electricity must be tempered by recognition of the recent and on-going deregulation of electricity production in Montana. Montana is one of 18 states that already have passed comprehensive legislation to restructure their utility industries.[175] Many of the old assumptions about how the utility industry works and how electricity production and use can be influenced no longer are valid. Strategies being suggested nationally may not apply here in Montana. To be effective, emission control strategies must be consistent with the competitive utility industry as it exists in Montana. (For a historical overview, see Appendix: Changing Structure of the Utility Industry, p.1)

Summary of conclusions: Most of the issues discussed in this chapter involve completing the restructuring of the electric industry. A more market-oriented system would favor energy efficiency and less carbon-intensive generating technologies to a greater extent than previously has been the case. Unbundling utility rates all the way down to metering would allow customers to choose the services they want. Setting transmission charges in ways that show where there is congestion would favor distributed generation, which tends to be less carbon-intensive.

A successful market system depends on knowledgeable consumers. If electricity suppliers label their product, consumers can choose power with less environmental impact, should they so desire. Training and education programs for builders and consumers would increase the demand for energy efficient buildings. State supported demonstration of small-scale distributed generation technologies, including fuel cells, and of energy management strategies for buildings would increase the demand for those. Provision of wind speed data would reduce the uncertainty of siting wind farms.

Some regulatory intervention still may be needed. Market-based regulation such as carbon taxes and tradable emissions permits signal the need to lower carbon emissions without mandating any specific tactic; these are discussed at greater length in Chapter 6, Carbon Taxes and Tradable Emissions Permits (p.1). Further refining the laws and regulations covering the program for utility funding of energy efficiency and renewables during the transition to a restructured industry would focus that regulatory program more on cost-effectiveness issues.

Finally, certain programs that have been discussed nationally, such as requirements that a portion of power generation be from renewables, or proposals to expand the provision of tax incentives for fuel switching and energy efficiency, may not be appropriate in Montana at this time.

4.2 Forecast of electricity production and use

The electric utility industry is driven by consumers' demand for electricity and the industry's search for profits. The amount and types of generation equipment existing today are a legacy of the decisions made in the past on how to serve consumer demands. Fuel types, generating technology, and plant locations are largely a result of efforts to control costs and to make profits in an era of regulation, when utilities were guaranteed a return on their investments, and there

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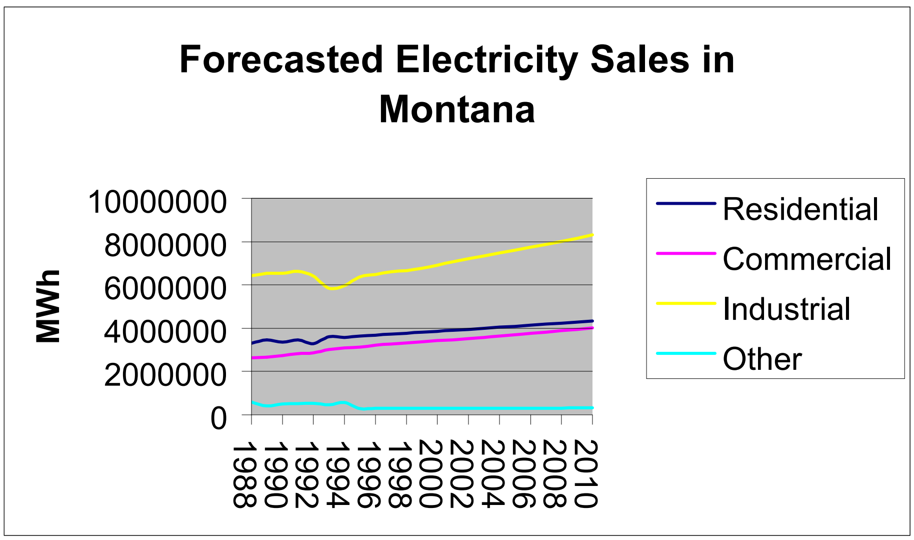
[175] National Council of State Legislatures (NCSL). The Energy Project: Restructuring and the Electric Industry. Updated June 14, 1999.

was virtually no competition for customers' business.[176] Decisions made by electric consumers have likewise left the legacy of technologies and demands for electricity that justified utility decisions to build the plants we have today. These decisions to invest in electric space heating, water heating, and other electric appliances, and to under-invest in insulation, weather tightening of buildings and high-efficiency industrial processes may at times have been driven more by considerations of first cost rather than long-term cost, much less by informed environmental concerns.

Restructuring of the electric utility industry makes it even more difficult to forecast the amounts of electricity that will be used or generated in Montana. DEQ is not aware of any current models that forecast sales in the Montana market. Montana Power Company did prepare a simple model that projected market trends from 1995 to 2002.[177] If those trends are assumed to continue, Montana will see sales of 16,963,400,000 kWh in 2010. This is an increase of 30 percent over sales in 1990. The forecasted sales trends by sector are shown in the following figure.



Based on sales projections by MPC for 1995 to 2002

Future trends in generation also are hard to predict. The existing plants will continue to operate as long as they are competitive in the regional market. New facilities will be built where and when their backers believe they'll be competitive. Any new facilities will be powered by fossil fuel or possibly by wind and solar. Most new generation facilities around the country are efficient combustion turbines or combined-cycle plants fueled by natural gas; any large facilities

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[176] The Colstrip plants, which constitute almost all the fossil-fuel fired generation in Montana, are the result of decisions by five utilities in the 1960s and early 1970s to capture economies of scale by sharing ownership of large mine-mouth coal-fired steam turbine generators (two 330 MW units and two 700 MW units, net capacity). The low-sulfur coal at the site enabled the plant to meet the clean air requirements in place at the time Colstrip was planned.

[177] Chris Marchand, Montana Power Company, personal communication with Paul Cartwright, DEQ, September 8, 1998.

built in Montana can be expected to follow this pattern.[178] Few if any environmentally and politically acceptable sites for major hydropower sites remain in Montana. Nuclear facilities currently cannot be permitted under the Major Facility Siting Act unless they are approved in a statewide referendum (MCA 75-20-201). New biomass-fired facilities are possible, but economical production of adequate amounts of biomass could be difficult in Montana's climate.

4.3 Strategies to reduce or offset utility industry greenhouse gas emissions

Reducing greenhouse gas emissions from the electric utility industry means addressing the legacy of past decisions and confronting the continued growth in demand for electricity. The options for change fall into three categories:

- Changing fuels within the utility industry
- Increased reliance on distributed generation
- Reduction in demand and the growth in demand

The tools that have the best chance of working in a competitive environment are those that rely on market mechanisms and those that affect all players in the market. Voluntary efforts like Integrated Resource Planning, for example, may point to investment choices that are socially optimal but not privately optimal. The changed regulatory environment will no longer support implementation of such plans. Where the traditional regulated utility could charge for all prudently incurred costs, power marketers who choose anything but the cheapest sources of power are at risk of being underbid and losing their customer base.

4.3.1 Changing fuels within the utility industry

The most direct way to reduce the amount of carbon dioxide emitted by Montana electric generators would be to switch to fuels with less carbon content, in both existing plants and any future plants. This is unlikely to happen for existing plants under current market conditions without regulatory intervention, because existing coal-burning plants are using relatively cheap fuels. At best, the current market appears to favor natural gas in new combustion generation facilities; otherwise, there are no clear reasons for generating companies to shift from their heavy reliance on coal. New reasons or incentives must be created for companies to make the switch.

New facilities presently must satisfy a variety of federal environmental regulations that affect the choice of fuel. Among these are the Best Available Control Technology (BACT) for SO_2 and NO_X, New Source Performance Standards (NSPS) for SO_2 and NO_X, and Tradeable Allowances for SO_2. Taken together, these regulations impose a significant economic incentive to choose low-sulfur fuels and low NO_X technology. With current prices the fuel of choice for new facilities is generally natural gas, which is a less carbon-rich fuel than coal. To reduce greenhouse gas emissions even further through fuel switching, the choice would have to shift to fuel cells or to renewable sources such as wind generation or photovoltaics. All of these

[178] Although natural gas-fired plants emit significantly less CO_2 per unit output than most older thermal generation, their selection to date has been a result of cost considerations and fuel prices and has not been primarily driven by environmental concerns.

currently have significant cost premiums that are difficult to overcome in the current competitive market.

Converting existing coal plants to run on natural gas in the current market theoretically would reduce carbon dioxide emissions by 45 percent, due simply to the lower carbon content of the fuel. The problem is cost. For instance, switching MPC's 156 MW Corette plant in Billings from coal to gas would reduce its CO_2 emissions from 1.11 million tons per year to approximately .61 million tons per year. The delivered cost of coal at Corette is approximately 54.3 cents/MMBtu. Natural gas delivered at the site costs 186.0 cents/MMBtu.[179] Switching the Corette plant to run on natural gas would reduce emissions by about .49 million tons per year but the increase in costs would be $13.9 million per year. The cost of CO_2 reductions would be $104 per ton of carbon.[180]

Converting the Colstrip complex, the largest coal generating facility in Montana with four units totaling 2060 MW of capacity, would be even more impractical. At peak output, the four Colstrip plants would require almost twice as much natural gas as MPC supplies to all its customers on the coldest day. Over the course of the year, the Colstrip plants would take almost 3 times as much gas as currently is sold in Montana. Colstrip is not near a natural gas trunk pipeline. The nearest large pipeline is a 12-inch line belonging to Montana Dakota Utilities, running along the Yellowstone River. However, such a line couldn't carry even a fifth of the amount of gas a Colstrip-size plant would require.

Given the current price of natural gas (see Chapter 5, Natural Gas, p.1), and the cost and ease of new plant construction, new facilities are likely to be efficient natural gas-fired plants, such as natural gas-fueled combined cycle plants, instead of coal plants. Under deregulation, this could lead to a major change in the timing of building plants. Under the previous regulatory system, plants were built as demand for power increased. In a deregulated market, plants will be built as they are profitable, which could be when demand increases or whenever new plants can displace more expensive power from an operating existing plant. However, the Montana coal plants are among the lowest operating cost plants in the region and they are unlikely to be displaced.

Renewables and fuel cells are dropping in price but are not yet competitive. These are relatively new technologies should benefit from the intense research and development already underway. They also should benefit from declining production costs due to increased production.

In sum, while the current market appears to favor natural gas in new combustion generating facilities, there are not yet financial reasons for generating companies to shift existing plants from their heavy reliance on coal. Further, while all generating facilities must comply with Montana and federal air and water quality laws and standards, there is currently no legislative authority under which the state could mandate fuel switching in existing facilities. Fuel choice in the unregulated generation sector cannot be affected by the Montana Public Service Commission taking direct regulatory action. With utility restructuring and the sale of Montana Power's generating facilities, the ownership of almost all facilities in Montana will be outside the reach of

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[179] U.S. Energy Information Administration. *Receipts, Average Cost and Quality of Fossil Fuels Delivered to US Electric Utilities by County and Plant*. January 1995.

[180] Costs of reducing greenhouse gas emissions usually are given in cost per ton of carbon, or per metric tonne of carbon. Multiplying by 1.1 will convert $/ton to $/tonne.

the PSC. The only coal plant under Montana jurisdiction will be Montana Dakota Utilities' 50 MW Lewis and Clark Station at Sidney.

In a deregulated market investors respond to price signals that reflect costs the market recognizes and the values of consumers. If prices fail to reflect true resource costs because some costs to society, such as environmental degradation, aren't included or because of other market failures, then some means must be found to provide proper signals to investors in generating facilities. Ways of changing those signals include carbon taxes, portfolio standards, carbon dioxide caps and tradeable emissions permits, tax incentives for reduced emissions by utilities, and state certification of green power ("truth in labeling").

4.3.1.1 Carbon tax

The most economically efficient tool to promote fuel switching in the generation of electricity is tax policy. Implementation of a carbon tax would change the relative costs of different fuels and technologies for generating and conserving electricity. Because the utility industry relies more on coal than any other industry, a carbon tax could affect it more than most industries.

Because a carbon tax could cover fuel uses for all purposes, not just electricity generation, it is covered separately, in Chapter 6, Carbon Taxes and Tradable Emissions Permits (p.1).

Conclusion from Chapter 6: The economic impact of different levels of carbon taxes on the Montana economy should be investigated before a state carbon tax is adopted. In particular, the impact of carbon taxes on the operation of generating plants in Montana should be modeled, both as a state tax and a national or regional tax covering the interconnected system of which Montana plants are a part. A national carbon tax that would be phased in appropriately and that would offset existing taxes might be the better option to explore.

4.3.1.2 Portfolio standards

Portfolio standards are requirements that some minimum proportion of power supplies be obtained from technologies with certain characteristics. These have been proposed as ways to enhance the market share of new renewable technologies and thereby reduce the overall environmental impacts from the generation of electricity. Renewable technologies have minimal or zero carbon emissions. Portfolio standards need not be limited to renewables, but could include less carbon-intensive technologies, such as fuel cells, which also reduce overall carbon emissions.

Portfolio standards have been promoted as a way to continue funding for technologies that are not yet cost-competitive but whose costs are expected to decline with near-term technological developments and with the economies of scale from expanded production. This is a market-pull approach, where by technologies with low or zero carbon output are guaranteed a market share. The standards should be structured so that each of those technologies and the companies supplying them must compete on cost and performance.

In a traditional, vertically-integrated regulated utility industry, regulatory pressure and guaranteed cost recovery made utilities amenable to regulatory and intervenor pressure to invest modestly in renewable technologies. Because there is no way for a competitive generator to recover costs that are higher than the market price, investing in new and promising technologies could endanger continued financial viability for generating companies. If deregulation of the generation sector is structured to include portfolio standards, all suppliers will be affected equally and no generating company will suffer a competitive disadvantage by supporting technologies that have environmental benefits.

Portfolio standards have been adopted in a number of states (including Arizona, Connecticut, Maine, Massachusetts, Nevada and Pennsylvania) in an effort to ensure continued support for renewable technologies.[181] Portfolio standards are included in the Clinton Administration restructuring bill, the Comprehensive Electricity Competition Act (CECA). CECA would require a gradual transition from current levels in 2000, rising to 5.5 percent of sales by 2010. Other competing bills by Senator Jeffords, Senator Bumpers, and Senator Schaefer would require renewable investments in amounts ranging from 4 percent (Schaefer) to 20 percent (Jeffords).

Portfolio standards have been supported vigorously by proponents of renewables, including environmental activists and the renewable energy industry. The industry would benefit greatly from a mandatory demand for their product regardless of cost or cost-effectiveness. A potential problem with portfolio standards is the evaluation of claims from the industry about future cost decreases and about the environmental costs and benefits of renewables. Advocates project great benefits from implementation and tend to discount any environmental disadvantages, such as noise and avian impacts from wind generators.

The impact of any future portfolio standard in Montana would depend on which resources were included in the definition of acceptable power sources. For example, almost half of power produced in Montana is from conventional hydropower, but only a minuscule amount is from wind, photovoltaics, or other renewable sources. CECA defines renewable sources as solar, wind, geothermal and biomass, thus excluding hydropower. (Senator Bumpers' bill would also allow partial credit for large hydroelectric plants over 80 MW.) Were Montana to follow CECA, and set the portfolio standard at 5.5 percent, a demand for 107 average megawatts[182] (aMW) of non-conventional power would be created by the year 2010, based upon the electricity demand forecast referenced above. Those new facilities might or might not be located in Montana, depending on where the most economical sites are and what the transmission constraints are on moving power to customers in Montana.

The costs of portfolio standards need to be assessed to determine if they are an economical means of reducing carbon dioxide emissions. The central problem for such an evaluation is selecting a timeframe for the analysis. One of the intents of a portfolio standard is to reduce long-term costs of non-conventional generation by guaranteeing a market sufficient to support research and the construction of economical-scale manufacturing facilities. Too short a timeframe will miss the benefits of supporting technological development; too long a timeframe could overstate the benefits of these technologies compared to carbon reduction strategies based on more mature technologies or options in other sectors. Montana's contribution to creating a market for new technologies is likely to be too small to have any significant impact unless it proceeds in concert with other states.

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[181] *State Renewable Energy News*, Vol 7, No. 1, Summer 1998.

[182] An average megawatt is equivalent to 1,000 kWh being used for one year, which is 8,760 hours.

In addition to reducing carbon dioxide emissions and other criteria pollutants by displacing conventional facilities, a portfolio standard could reduce consumption if it imposes extra costs on customers. Faced with those costs, customers will reduce their consumption of electricity somewhat.

A portfolio standard was proposed and discussed during the legislative debates over the recently passed Montana utility deregulation bill, but the Legislature declined to include it in the bill as passed. DEQ doubts there would be any immediate interest in implementing a Montana portfolio standard at this time.

Conclusion: Utility portfolio standards probably should not be included as one of the first steps in dealing with greenhouse gas emissions in Montana.

4.3.1.3 Tradable emissions permits

Tradable emissions permits ("cap and trade") system sets a limit on total emissions of some pollutant and establishes allowances, or "rights to pollute," which can be traded on the open market. Tradable permits have been used in the United States since 1995 as part of the successful effort to economically control SO_2 emissions from utilities. A tradable permits system would work better on a national than a state level.

The number of fossil-fuel fired generating plants is relatively small: around 2000 in the United States, roughly 300 larger than 50 MW in the Western Interconnection, the transmission grid covering the western United States and Canada and northwestern Mexico. Because of their small number and relatively large emissions, these plants are likely to be the first target of a tradable permit program. A minimum area for effective coverage would probably coincide with the Western Interconnection.

Tradable emissions permits theoretically could be required of many industries and are covered separately in Chapter 6: Carbon Taxes and Tradable Emissions (p.1).

Conclusion from Chapter 6: DEQ should monitor development of national and international tradable carbon emissions permits programs as part of market-based approaches to controlling greenhouse gas emissions.

4.3.1.4 Tax incentives for reduced emissions by utilities

Several different tax incentives have been suggested to encourage utilities to reduce greenhouse gas emissions. They would work by lowering the price of low-carbon fuels relative to high-carbon fuels and thus encouraging utilities to switch fuels. These include expensing or rapid depreciation of investments that reduce greenhouse gas emissions, and direct tax credits for reductions in greenhouse gases.

Expensing and rapid depreciation are indirect incentives that provide benefits for investing in equipment, as distinct from direct incentives that reward reductions in CO_2. They would provide benefits in proportion to capital expenditures regardless of the extent of greenhouse gas reductions. Further, these tools would provide no incentive for no cost or low-cost reductions that do not require significant investment, ones that may be more promising and effective means of reducing greenhouse gas emissions. Direct tax credits for greenhouse gas reductions would, by contrast, leave intact the utilities' incentive to minimize costs and to select the most cost-effective reduction strategy.

A major problem with tax incentives is that the cost of the incentives is borne by the taxpayers of the state, rather than by those consumers of electricity creating the problem. In the absence of a coordinated global strategy or near-universal voluntary actions by all parties, Montana taxpayers would receive little benefit for their expenditures and would be subsidizing electricity users and other jurisdictions. Direct tax credits for greenhouse gas reductions might be an effective part of a coordinated national or multinational program.

Conclusion: Utility tax incentives probably should not be included as one of the first steps in dealing with greenhouse gas emissions in Montana. DEQ should monitor any national or multinational efforts to use tax credits as part of a coordinated strategy.

4.3.1.5 "Truth In Labeling" activities – Environmental disclosure and state certification of green power

"Green power" is electricity produced in ways that minimize environmental impacts. Offering green power allows utilities to involve consumers directly in the process of lowering harmful emissions. "Green goods" including foods, appliances and household cleaners are a fast-growing phenomenon in markets worldwide. U.S. DOE's Green Power website reports on the wide range of green power activities in the United States. Surveys conducted in various places around the country indicate there is some market for green power. The National Renewable Energy Lab reports that between 15 and 30 percent of residential customers participating in pilot choice programs have chosen to purchase green power.[183] Companies in many states are using the "green power" label as a way of differentiating their product. Investor-owned utilities, such as Public Service Company of Colorado, are offering green power along with their other products.[184] Green power is being marketed in Pennsylvania and California by a number of independent companies. While green power initially sold for a .5 cent to 2 cent premium in California it is now being marketed at about a .5 cent discount below the California Power Exchange (PX) index price. (However California offers a 1.5 cent/kWh credit to purchasers of renewable energy.) In California several large commercial customers, such as Toyota Motor Sales and Patagonia, have chosen to purchase green power.

In California, the independent Automated Power Exchange (APX) has developed an innovative way to streamline the marketing of green power. In May 1999, APX adopted a "Green Ticket" approach, whereby green power is traded in two components: 1) the commodity energy and 2) the green premium as represented by the Green Ticket. The commodity energy is traded up to a week-ahead and scheduled in hourly blocks; the Green Ticket is traded in a calendar year market

[183] Blair Sweezy and Ashley Houston. *Information Briefing on Green Power Marketing*. Third edition. National Renewable Energy Laboratory, September 1998.

[184] In January 1999 PSCo announced that the first seven wind turbines installed to provide power for the company's Windsource program were generating electricity for the first 2,000 program subscribers. In total, 9,000 of the utility's customers have signed up for the program. Participating customers can purchase 100-kWh blocks of wind energy to meet some or all of their electricity needs at a rate premium of $2.50 per block per month. Current plans call for a total of 16 MW of wind generating capacity to be installed at the site to serve the program.

corresponding to the tracking and verification procedures of regulatory agencies.[185] This approach allows the actual sale of electricity (the commodity market) to proceed unimpeded, while at the same guaranteeing that the market will recognize the value of green power production and that green producers have the maximum incentive to lower the cost of their product.

A potential barrier to marketing is the difficulty of convincing customers that the marketing claims are valid. Power cannot be seen, and there is no difference at the plug between clean power and dirty power. Experience in the organic and ecolabeled food market has shown, however, that there are ways to overcome this problem.

One approach to this issue is to require environmental disclosure of all power marketers. Environmental disclosure rules under consideration around the country would require all power marketers and power suppliers to provide information on SO_2 and NOx emissions.[186] The Montana PSC is in the process of adopting rules for consumer information and protection. These would require power marketers to document and substantiate any claims they make about the environmental benefits of their power. The Commission may investigate these claims on its own or in response to complaints, and may apply penalties, including license revocation, for false or misleading claims. Greenhouse gases are not generally included in disclosure requirements, although there is some correlation between criteria pollutants and CO_2. Inclusion of a CO_2 disclosure requirement would enhance energy efficiency decisions in the environmentally sensitive market segment. Adding a CO_2 disclosure requirement would have minimal impact on the cost of compliance.

A second approach is to offer state certification of green power, with the state taking a more active role. Third-party certification from a trusted and well-known federal agency or private organization also might work. In California, the Center for Resource Solutions administers the "Green-e" certification, which covers 11 of the 15 green power marketers as well as the APX. Certification can be indicated on a product by a seal of approval. Such a seal could include both the name of the certifier and a brief description of how the power is generated more cleanly. Such information might also explain why a price premium is charged for that power. Because power is not available in a packaged form upon which a seal can be placed, the information to consumers might be best communicated on an insert included with the power bill. The biggest question to be addressed in the case of certification is what types of information to give consumers. Depending on the certification requirements, adoption of this approach would provide consumers with greater certainty about the nature of the resources used in generating the power being acquired and marketed by their service provider. Ensuring that third party certification is truly independent could be a major problem.

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[185] Janis C. Pepper. "Opportunities For Biomass In The APX Green Power Market." Automated Power Exchange, Inc. Presented at the Fourth Biomass Conference of the Americas, Oakland, California. August 29 – September 2, 1999.

[186] See, for example, David Moskovitz, et al. *A Summary of Research on Information Disclosure: Synthesis Report*. October 1998.

Green power marketing offers emission reductions to the extent that consumers' response makes green power profitable. However the size of the potential market for green power is unclear, and green power is likely to be at best a partial solution for reducing greenhouse gas emissions.

Conclusion: Encouraging green power marketing by licensing and certification of marketers, either by establishing appropriate state reporting requirements, or by encouraging private certification agencies such as CRS to operate in the state, would protect consumers and promote the use of green power. DEQ should support PSC efforts to require environmental disclosure by energy suppliers, both in advertising and marketing efforts and on utility bills. DEQ should track the progress and development of green power in other states.

4.3.2 Increased reliance on distributed generation

A second way to reduce greenhouse gas emissions in the utility industry would be to shift from reliance on large, central station power plants to smaller generating plants scattered around the transmission grid closer to the loads they serve. Distributed generation can reduce greenhouse gas emissions if it uses high efficiency, natural gas-fueled cogeneration or fuel cells, or renewable sources, such as wind turbines and photovoltaics. These technologies are not well suited to large central station applications but appear appropriate for small distributed applications. Because the waste heat from electricity generation can be used on-site, cogeneration and fuel cells emit far less carbon dioxide per unit of energy delivered than do conventional power plants. Renewable facilities can be sited to take maximum advantage of localized resources, which reduces the cost of generation. Finally, because distributed generation is located at or near the site of use, there are almost no losses in delivering power. In comparison, approximately 8 percent of the electricity from a large central station are used up in transmission to the customer.

The reductions in carbon dioxide emissions from distributed generation can be substantial. The major benefit of distributed generation from combustion technologies is its ability to be sited close to loads that can use the waste heat. Distributed natural gas-fueled, internal combustion cogeneration would produce approximately 25 percent of carbon dioxide emitted (per million kWh) of a coal-fired plant like Colstrip or 61 percent of the emissions per million kWh of a natural gas combined cycle plant.[187] For fuel cells, the reductions would be 32 percent and 79 percent, respectively.[188] Natural gas cogeneration is a relatively mature technology that currently

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[187] A 10 MW distributed internal combustion cogeneration plant would produce 644 tons of CO_2 per million kWh, or 39,490 tons per year. If the plant displaced or delayed a large centrally located coal-fired generating plant, it would displace 96,722 tons of CO_2 per year, including an offset of 8 percent transmission and distribution losses. The waste heat capture through cogeneration would offset an additional 26,522 tons in direct natural gas combustion. If the large centralized plant displaced was a natural gas, combined cycle plant, CO_2 displaced would be approximately 39,499 tons a year (including reduced transmission losses), plus 26,522 tons due to offset direct gas combustion for heat.

[188] Fuel cells produce approximately 396 tons of CO_2 per million kWh. A 10 MW fuel cell would produce about 31,204 million tons of CO_2 per year and would offset approximately 96,737 tons of CO_2 from central station coal generation plus about 12,238 tons from waste heat capture offsetting direct natural gas combustion.

The saving is lower if the distributed generation is a combined cycle plant, because the heat rate is fairly high for a small plant (9500 Btu/hr for a 10 MW plant) and there is much less useable waste heat (only 1200 Btu/kWh). The net charge to electricity is 8300 Btu. Even with the transmission and distribution benefits there is no net saving in suffers mainly from market barriers facing any kind of distributed generation. Fuel cell technology is currently nearing commercial availability in sizes ranging from several kW to 1 MW.

Distributed generation has not received a great deal of attention from the utility industry, possibly because of the administrative burden of managing large numbers of small dispersed generating plants.[189] The conventional approach of utilities has been to look only at aggregate loads for the purposes of generation planning. The utility then built at a location that minimized capital costs of plant construction, transmission lines (if needed to connect a plant to the utility grid), and operating costs, which are largely the direct costs of delivered fuel. Transmission systems have been planned separately from generation, using a different set of criteria. The transmission system has been considered adequate if, given the sizes and locations of loads and generating plants, all loads can be served even with the strongest single transmission line out of service. As loads grow and generation is added, new transmission lines are occasionally required to maintain reliability across the system. Costs have been recovered through fixed per kWh charges in customer power bills and through "postage stamp" wheeling rates (where a single fee per transaction is charged regardless of the origin and destination of power flows) for other utilities. Joint planning of generation and transmission generally has not been the rule, and there has never been efficient pricing of transmission access and congestion.

This system presents an inherent barrier to distributed generation. Without efficient transmission pricing it is not possible to determine the value of dispersed generation or where to put it, and it is impossible for a third party investor to recognize profitable locations for distributed investments.

Investment in distributed generation can be supported both by improving the market signals on the actual costs of conventional generation and transmission, and promoting development of distributed generation technologies. Ways of doing these include unbundling utility rates and separating utility functions, setting economically efficient transmission charges and using efficient methods of clearing congestion on the transmission system, and supporting investments in cost-effective renewable energy technologies.

4.3.2.1 Unbundled utility rates and separated utility functions

Fully unbundled utility rates would allow customers to purchase only the services they need, and would allow distributed generators to buy ancillary services and backup power without having to pay high customer charges and capacity charges. Fully separated utility functions would allow distributed generators to interconnect without obstruction, since the connecting utility no longer would be the one faced with lost power sales.

Functional separation and unbundled rates were envisioned as part of Montana's restructuring legislation, but so far only Montana Power has made progress on either of these issues. MPC's asset sale, scheduled to close late in 1999, will result in a fully separated energy supply function,

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CO_2 if the central generation displaced is also a combined cycle plant. If the displaced power is coal-fired, there is still a significant saving, almost 43,000 tons per year.

[189] One exception is the research and demonstration projects funded by the Electric Power Research Institute (EPRI) and Pacific Gas and Electric (PG&E).

and will likely result in fully separated energy supply rates for most customers. Less progress has been made on full separation of energy services from transmission and distribution. The Public Service Commission has promised to establish a docket on this issue to determine how to implement the legislative requirements. The issue is important because competitive provision of metering and billing are key to making competitive supply of energy profitable in the residential and small commercial customer sectors. Monopoly control of these services would make effective competition for small customers unlikely. These customers then could be open to monopoly pricing abuse with no regulatory oversight. In addition, competitive metering will allow customers to invest in advanced meters that make purchase of time-of-day priced electricity and other new services possible.

It also is essential that unbundled pricing for transmission and distribution (below) and for energy services (see p.1) truly reflect the marginal cost of service in order to remove any incentives for the utility to oppose the installation of distributed generation. If these services are simply priced on an average cost per kWh basis, the utility will be penalized by, and will oppose, any action taken by consumers that reduces metered sales.

Conclusion: DEQ should continue to monitor the implementation of unbundled prices for energy, transmission and distribution charges, and energy services by MPC and to encourage the Montana PSC to require that prices be efficient and reflect the marginal cost of service.

4.3.2.2 Economically efficient transmission charges

Economically efficient transmission charges are prices that accurately reflect the cost of moving a block of power from one point to another. Economically efficient transmission charges would highlight the locations on the utility grid where distributed generators can reduce congestion. This would provide additional financial incentive to build such generating facilities.

Historically, vertically integrated utilities have built and operated their transmission and distribution networks to deliver power from their generating plants to their customers. They have allowed other utilities to move (“wheel”) power through their systems, generally at “postage-stamp” rates (fixed charges per kW that are not affected by the location of entering and leaving the system or of the degree of congestion on the system). Commercial transactions have been accepted across the network if power suppliers purchase access along a contractual path connecting the point of input to the network and the point of delivery to the customer. These arrangements are inconsistent with the physics of electric transactions and with the marginal cost of carrying the transactions. Electricity does not flow over contractual paths, but flows over all segments of an interconnected network, and it flows without regard to who owns the lines.

Several problems relate to this inconsistency between the commercial and physical aspects of the transmission network. First, the charges accrued along a contractual path are the sum of the postage stamp rates of the utilities on the path, which bear no relation to the cost of using the transmission paths actually taken. This adding (“pancaking”) of rates can result in high charges that can render already low profit transactions uneconomic. Second, the scheduling of transactions along a contract path can reduce the ability of utilities off the contract path to use their own systems, even though they were neither informed of nor paid for the inadvertent use of their transmission lines. Third, congestion is managed without regard to price or to the value of transactions, but rather by simply blocking some transactions and limiting the available capacity.

Distributed generation offers the greatest advantage at locations where it relieves, rather than contributes to, congestion. The current system of pricing transmission and of managing congestion provides no price signals that would encourage investment in distributed generation. Instead it signals that there is no cost to using congested paths. Efficient pricing of transmission would provide the signals that would tell where distributed generation should locate and would provide financial incentives to build at those locations.

There is widespread recognition that the present method of transmission pricing must change if competitive markets in electricity are to work. FERC has ordered all utilities under its jurisdiction to file open-access tariffs that provide service to others comparable to the service they provide to their own power divisions. (Compliance has been less than perfect, leading in some cases to FERC penalties.) FERC is also currently considering rules that will speed up the formation of Regional Transmission Organizations (RTOs) that will operate, price and control access to large segments of the interconnected transmission grid. The proposed rules require pricing and congestion management methods that eliminate pancaking and provide efficient price signals.

Voluntary efforts to form RTOs have been underway for several years, with mixed success. For example, in 1997 utilities and state regulators and energy policy staffs from Colorado to Washington developed a proposal for IndeGO (Independent Grid Operator), a non-profit organization that would have leased and run the transmission network in the northwestern U.S.. This proposal included economically efficient pricing and congestion management methods and would have eliminated pancaked rates. It would have separated the recovery of sunk capital costs into annual load-based dues, and the only transaction-specific charges would have been congestion fees on specific segments. The IndeGO proposal foundered because of fears of cost-shifting as the organization moved to uniform rates over a ten year period, and because of concerns from utilities in some state that their regulators would oppose any moves that could increase the competitive demand for their low-cost generation. However the interest in forming an RTO continues and will probably be galvanized by FERC's proposed rule making.

Conclusion: DEQ should continue to encourage the implementation of RTOs and to ensure they adopt efficient pricing and congestion management systems.

4.3.2.3 Support for investments in distributed generating technologies

Many of the current and proposed changes in how electricity is marketed could make distributed generation more economically attractive. Montana also could consider more direct support for these technologies.

Renewable energy technologies probably receive more public attention than other distributed technologies. Renewable energy technologies tap the flow of energy from the sun, either directly, or in the form of wind, hydro or biomass.[190] Large dams on rivers currently provide almost half the electricity generated in Montana. In the future, the form of renewable energy

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[190] Geothermal energy, heat from within the earth, also is considered a renewable energy, but is not widely available at temperatures suitable for generating electricity.

most likely to be used for distributed generation is wind.[191] The state could offer more support for wind, either as direct financial assistance, or by reducing uncertainties about where best to site wind farms.

Montana already has a substantial tax credit to support wind development. Montana allows 35 percent of eligible costs to be taken as a tax credit against Montana income from investments in wind farms and related facilities.[192] In the last five years, only minor amounts have been claimed as credits against personal income taxes and no commercial-scale facility has used the credits. The credits apparently haven't been sufficient to overcome the high cost of producing power at Montana sites, many of which are in isolated areas far removed from major load centers. With the deregulation of power generation and the increasing attractiveness of distributed generation and green power, it's likely that more credits will be claimed in the future.

Legislation passed in Montana's 1999 legislative session authorized "net metering" for customers with small, on-site generators using renewable energy.[193] Net metering means the customers can "run their meters backward" when they generate more energy than they need for their own use. In concept, net metering could stimulate growth in distributed generation. However, the new legislation limits net metering to on-site plants with 50 kilowatts generating capacity, enough power for only a few residences. Few commercial electric users will be interested in the economics of cogeneration units that small. More importantly, net metering is limited to on-site solar, wind or hydro- electric generation, and does not apply to fuel cells or natural gas-fired plants.

During the 1980s and the early 1990s, the Montana Department of Natural Resources and Conservation (now DEQ) conducted significant amounts of research to answer questions about siting wind farms in Montana. DEQ extended work done by U.S. DOE with long-term studies of wind speed and wind shear in the area south and east of Livingston. DEQ conducted its own wind monitoring program at eight sites around the state. Data from these studies, the National Weather Service, the Federal Aviation Administration, the Bonneville Power Administration, and air quality studies from various agencies and companies are summarized in the *Montana Wind Energy Atlas, 1987 Edition*. DEQ's monitoring identified Norris Hill, near Ennis, as a potential site, with a two-year average windspeed of 17.0 miles per hour, at 10 meters, and

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[191] Photovoltaics may have a role in niche markets. DEQ will continue to participate in U.S DOE's Remote Photovoltaic Demonstration Project. Current plans are to expand the demonstration of PV pumping stations as alternatives to dewatering on impaired rivers and streams, and to support the demonstration of PV in public places such as Makoshika State Park near Glendive. DEQ also pledged support to the long term planning for increased utilization of solar technologies in the state as part of DOE's Million Solar Roof Project. DEQ's involvement with the Greening of Yellowstone and the Greening of Glacier Park may provide more opportunities to expose the public to the benefits of the remote and distributed power capabilities of renewables in the right applications.

[192] See Montana Codes Annotated 15-32-402, Commercial investment credit—wind-generated electricity. The credit also may be claimed for income from manufacturing plants located in Montana that produce wind energy generating equipment or from a new business facility or the expanded portion of an existing business facility for which the wind energy generating equipment supplies, on a direct contract sales basis, the basic energy needed. Eligible costs include the purchase, installation, or upgrading of generating equipment, safety devices and storage components, transmission lines necessary to connect with existing transmission facilities and transmission lines necessary to connect directly to the purchaser of the electricity when no other transmission facilities are available.

[193] SB 409, amending Title 69, Chapter 8, Electric Utility Industry Restructuring.

relatively good access to transmission lines. A partnership composed of the Montana Power Company, a nationally known wind energy company, DEQ, and Montana State University conducted a study of avian use of the area, to assess the likelihood of avian mortality were a wind farm to be built. The first year of the study relied on manual observation of bird movement during daylight hours and concluded that there was not extensive use of the area. During the second year of the study, marine radars were used to track bird movement through the potential wind farm. Results of the second year of study revealed significant use of the area by migratory birds in the early predawn and post sunset hours. Lack of funding hindered further development of the radar tracking system and follow-up study.

Many companies have expressed interest in building wind farms in Montana. Montana Power Company went so far as to draw up plans for a renewable energy park at Norris Hill and some wind companies conducted monitoring there. However, no major investments have followed from the support state government has offered. This may yet change, as the restructuring of the electric industry opens new options and allows the value of distributed generation to be seen more clearly. A new program proposed by U.S. DOE also may spur new interest in wind energy. Wind Powering America has the goal of providing 5 percent of the nation's electricity with wind power by 2020. This push by DOE, combined with the rapid growth in the wind industry outside the United States, may be sufficient to promote technology development that lowers the price of wind electricity.

Fuel cells, which convert fuel to electricity chemically, show much promise for distributed generation, even down to the house level. BPA recently unveiled plans for a demonstration project for residential scale fuel cells. Initially, these cells will be fueled with methanol, with later installations using natural gas. The first phase of the program, starting during the fall of 1999, will see 10 prototype installations around the Northwest. These units produce 3 kW (continuous) as well as domestic hot water. The second phase, to begin in the fall of 2000, envisions 100 installations around the region. BPA estimates the production cost per unit in phase 2 at around $30,000 and expects the cost of the next 1,000 units to fall to around $10,000.

Finally, conventional technology such as internal combustion engines is being adapted for distributed generation. These microturbines are sized to produce 25 to 200 kW. They capitalize on advances in automotive turbochargers, auxiliary power units for aircraft and small jet engines. Microturbines appear to have good potential in Montana's larger commercial systems that need emergency backup, such as hospitals. Buildings that to this point were too small to consider cogeneration possibilities can use this technology to utilize waste heat from HVAC or other building processes. These technologies could be incorporated in DEQ's State Buildings Program (see p.1) and other programs working with institutional building owners.

Conclusion: DEQ should maintain the existing data on wind energy sites in forms that would be useful to future developers. DEQ should assess the feasibility of wind monitoring at high-potential sites, those with good wind resources and good access to transmission, that were identified by previous monitoring programs. DEQ should follow the progress of BPA's fuel cell demonstration program and encourage Montana utilities to participate in the program. DEQ should routinely include an assessment of distributed generation in its programs with commercial and institutional buildings.

4.3.3 Reduction in demand and demand growth

The third way to reduce greenhouse gases in the utility industry is to reduce the demand for electricity. Investments in efficiency can reduce the amount of electric power needed to perform specific tasks or to meet specific end-use demands for power. Past decisions about electricity generation and use have left Montana with significant opportunities for relatively low cost, high payoff investments in energy efficiency.

4.3.3.1 Energy efficiency potential

A major effort was mounted in Montana and in the Pacific Northwest in the 1980s and early 1990s to determine the potential amount of cost-effective energy efficiency investments that could be made, and to make as many of them as possible. This effort, led by Bonneville Power Administration (BPA), and overseen by the Northwest Power Planning Council, resulted in substantial investments in energy efficiency. In the Pacific Northwest region, which includes western Montana, over 1400 aMW of efficiency improvements had been made as of 1997, the most recent year for which estimates are available. This is more than the output of Colstrip 3 and 4, and equal to approximately 8 percent of sales in the region that year.[194]

In spite of all this work, considerable opportunities remain for energy efficiency investments that are cost-effective right now. With help from the Northwest Power Planning Council, DEQ was able to adapt the analysis done for the last regional plan to assess the electric energy efficiency potential in Montana residences and irrigation. DEQ assessed the potential assuming that the alternative would be purchasing electricity costing $0.025 per kWh, the price of electricity from a new natural gas combined-cycle turbine. Even at this price, DEQ estimated that 67 aMW could be saved in the residential sector (about 16 percent of 1998 residential sales in Montana), mostly in appliances and lighting. Another 6 aMW could be saved by irrigation equipment improvements including sprinkler pump impeller replacement, computer scheduling of sprinklers and the remaining conversion of center pivot to low pressure sprinklers.[195] The commercial and industrial sectors are believed to also contain considerable amounts of cost-effective potential investments in energy efficiency.

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[194] Northwest Power Planning Council. *Nutrack 98*. (forthcoming)

[195] Because pumped irrigation systems operating at low efficiency with poor designs often cannot supply enough water to sustain optimum crop yields, the economic benefits from improved efficiency can include improved crop yields as well as lower power costs. For additional information, see the Montana Irrigation Management Program, sponsored by the Broadwater Conservation district and numerous other state and federal agencies.

Residential Appliances	29.2
Residential Lighting	14.6
Existing Single Family Space Heating	16.0
Existing Multifamily Space Heating	3.5
New Single Family Space Heating	1.1
New Multifamily Space Heating	0.4
New Manufactured Housing Space Heating	2.3
Residential Sector Total	**67.1**

4.3.3.2 End use fuel switching

Encouraging more buildings, especially new buildings, to use natural gas instead of electric heat would reduce greenhouse gas emissions. Electric heat is cheaper to install than natural gas, but much more expensive to operate. Electric heat is often the choice in rental situations, when building owners are not responsible for paying the heating bills. The state could mandate the use of natural gas where it is available or offer financial incentives to install or retrofit natural gas heat. The first is politically unacceptable and the second would be needlessly expensive, since the incentive is likely to be claimed by many people who would have installed natural gas in any event. The use of natural gas also is tied to the availability of natural gas distribution lines. More compact, less sprawling development would increase the number of buildings that could be served economically with natural gas. Design measures discussed in Chapter 3, Transportation and Urban Design, could increase the use of natural gas.

Conclusion: Mandated end-use fuel switching does not seem an appropriate way to reduce greenhouse gas emissions at this time.

4.3.3.3 Direct use of USBC funds

Montana electric utility restructuring legislation provided for a Universal Systems Benefit Fund to ensure continued support for low income weatherization and payment assistance programs, energy efficiency programs and renewable resource development. The fund will operate over a four-year transition period as the utility industry restructures. The fund is financed by a Universal Systems Benefit Charge (USBC) on all electricity sold in Montana, with the total amount to equal 2.4 percent of each utility's 1995 retail sales revenue. The annual charge for customers with loads greater than 1000 kilowatts is the lesser of $500,000 or $0.0009 per kilowatt-hour purchased. The fund is to be set up with Public Service Commission oversight and approval. The legislation specified that at least 17 percent of the USBC go to low-income programs.

Utilities and large customers receive credit toward their universal system benefits obligation for their own investments in energy efficiency, renewable energy or low-income assistance. If a utility's or a large customer's credit does not satisfy the annual funding requirement, then it must make a payment to the universal systems benefit fund or to the universal energy assistance fund. It is unclear whether there will be any shortfalls and hence, whether there will be any payments to a statewide fund. Cooperatives may collectively pool their credits statewide. If their pooled credits do not cover their collective USBC obligation they must contribute the shortfall into the statewide fund. How such a shortfall would be allocated among the cooperatives has not yet been determined. Investor owned utilities and cooperatives must file annual reports relating to universal systems benefits to the transition advisory committee created by this bill.

The Montana Public Service Commission is not required by the law to adopt rules governing the USBC programs but staff indicates that such rules may be considered. The USBC programs were supposed to begin on January 1, 1999. On February 4, 1999, the PSC issued an order directing MPC to spend 29 percent of its USBC revenues on large customer rebate programs, 21 percent on local conservation programs run by the utility, 13 percent on market transformation, 21 percent on low income programs, 13 percent on renewables, and 3 percent on research and development, based on an estimated total of $8.56 million per year.[196] MPC's conservation funds go largely to the Northwest Energy Alliance for market transformation activities, with little direct immediate impact on energy use but potentially large long-term benefits.[197] MPC has also formed a USBC advisory group with the charge to recommend criteria and uses for the funds. The PSC has been working with Energy Northwest, Inc. (ENI, the regulated subsidiary of the Flathead Electric Cooperative that owns the former PacifiCorp service territory in Montana) and Montana Dakota Utilities to ensure that their USBC programs meet the minimum requirements of the law.

On July 12, 1999 the Montana Department of Revenue (DOR) filed a Notice of Adoption of Temporary Emergency Rules relating to Universal System Benefits Programs with the Secretary of State. The rules define eligible expenditures and cost-effectiveness, among other terms, and set guidelines for credits and expenditures for each of the programs. They establish a presumption that claimed credits are eligible and place the burden of proof upon any party seeking to challenge a claimed credit. A significant feature of the rules is a requirement that eligible renewable investments must be environmentally benign, and that project benefits must be included in any claim for credit. While displacement of greenhouse gases is not listed in the examples cited, it would appear to qualify easily.

A potential problem with the USBC programs is that no cost-effectiveness criteria are applied to renewable USBC expenditures. The DOR rules specifically define the allowable portion of renewable expenditures as the portion above the value of the energy produced, that is, the portion that is not cost-effective. While the intent may be to foster the development of renewable technologies that may not yet be cost-effective but that show great promise, the lack of any cost criteria leaves open the possibility of wasted effort. The rules would allow investment in an inferior technology while ignoring others that showed much greater promise.

In a restructured utility industry with retail competition, there may be marketing advantages in supplying energy efficiency expertise and financing. Further, because USBC funds must be spent or paid to the statewide fund, distribution utilities might be willing to invest in eligible distributed generation that otherwise would have been unattractive to them. However, there are a

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[196] Montana Public Service Commission Order 5986g, Docket No. D97.7.90, February 4, 1999.

[197] The Northwest Energy Alliance is a non-profit consortium of utilities, governments, public-interest groups and the private sector working to transform markets for energy-efficient products and services.

number of unanswered questions about distribution utility ownership of generation facilities, even distributed ones, and possible undoing of functional separation.

Conclusion: DEQ should monitor the development of the USBC programs and the implementation of the DOR rules, as well as any future rules adopted by the PSC. DEQ should consider proposing changes to the restructuring legislation as appropriate to increase the likelihood that funds are spent where they will have the greatest benefit.

4.3.3.4 State demonstration of end-use energy management

For most organizations, energy use is a small portion of overall expenses and rarely a part of the main mission. Management can have difficulty focusing on energy use and efficiency. There are tools that can improve energy management. These include enhanced energy monitoring, use of energy service companies (ESCOs), and contracting for energy services. State government can employ these tools, both to increase its own energy efficiency and to demonstrate the possibilities to local governments and to the private sector.

4.3.3.4.1 Enhanced energy monitoring

Energy monitoring is not a new concept. However, assembling and distributing data has been costly and difficult. The information hasn't always reached building managers in a timely and comprehensible manner. The increasing power and declining cost of computers, and the ability to move data easily over the Internet means these problems may now be resolved. The deregulation of the utility industry should make it easier for customers to get the information and services they need.

Through the Montana Rebuild America program,[198] DEQ is developing a demonstration project to assess the benefits of enhanced energy monitoring for a limited number of existing state, local government and commercial buildings. The project will select one of the industry-accepted software programs available for assessing fuel use and fuel cost, such as Illinova's Utility Manager or Avista Utilities. These programs track and benchmark the whole range of utilities and services—electricity, solid waste, water, natural gas, recycling and sewer. The enhanced energy monitoring would be done at the agency level in support of improving the decentralized operation and maintenance decisions that affect energy use and energy cost. Periodically, agency data would be collected at the state level to allow further analysis.

The first goal will be identifying processes to electronically retrieve energy and environmental data from utilities and building managers. Data transfers must be highly automated, since building and fiscal managers are unlikely to waste scarce staff on what to them are secondary objectives. The second goal is to customize commercially available software and demonstrate ways to distribute information that would improve the feasibility of decentralizing responsibility for energy use. The information has to be timely, and it has to be in a graphic form that is

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[198] The Montana DEQ Rebuild America Program helps local governments, communities and the commercial sector assess and plan investments in energy related improvements to reduce energy use and save on utility bills. The federal Rebuild America Program, through the DEQ Rebuild program, provides partners with technical assistance regarding bid evaluations, reviews of energy audits, sources of financing, contract negotiation, construction oversight and post-retrofit monitoring and evaluation.

readily deciphered by people who are not energy experts. Finally, the enhanced monitoring would improve the energy efficiency of investments made by state government. Because the monitoring will cover multiple buildings, energy use can be compared to identify highly efficient buildings, which can be used as models, and to identify high use buildings that should be retrofitted. The monitoring results should increase confidence in estimates of energy savings from retrofit projects, thereby making such projects more marketable.

The DEQ Rebuild America demonstration project should be in place by January 2000.

4.3.3.4.2 Energy service companies

Energy service companies (ESCOs) improve the energy efficiency of a building in return for a portion of cost savings those improvements cause.[199] An ESCO will train the building's operating staff, provide long-term maintenance services and invest in new energy equipment, such as lights, controllers and air handlers, to reduce the energy use of a building. The ESCO guarantees that savings meet or exceed annual payments to cover all project costs, usually over a contract term of seven to ten years. ESCOs have not been as active in the western states as elsewhere, but this is changing. By 1997, the industry had grown to the point that it was able to form the Western Regional Coalition of Energy Service Companies, to set standards and to promote performance contracting.

State government, through the State Buildings Energy Conservation Program, acts as its own ESCO. The Legislature issues bonds to finance the work. The program began in 1989. By September 1998, the program had completed 37 projects. An additional 20 projects were in different stages, ranging from the study phase to construction. The program has spent about $3.4 million in Stripper Well oil overcharge funds and about $3.6 million in general obligation bond proceeds to fund the projects and to operate the program. Cumulative utility bill reductions captured since the start of the program through June 1998 totaled more than $2.4 million. Nearly $730,000 in savings was anticipated for the 12 months ending in June 1999. The cumulative projected energy savings from the first year of each project were 9.6 million kWh and 66,000 MMBtu of natural gas.

DEQ also is using the federal Rebuild America Program to encourage the use of ESCOs in Montana. The Rebuild America Program helps local governments and communities reduce energy use and save on utility bills by making facility improvements such as building recommissioning[200] and lighting upgrade retrofits. As part of the Montana Rebuild Program, DEQ partnered with the National Center for Appropriate Technology (NCAT) to oversee Rebuild America projects. The county courthouse, jail and a public housing complex are being packaged as a prototype project in Butte. Bids have been solicited from ESCOs for a pilot project to improve building energy performance. The contract should be in place by fall 1999 and the retrofits completed by spring 2000. The Montana Partners for Energy Efficiency (DEQ,

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[199] An overview of ESCOs may be found at U.S. DOE's Rebuild America Financial Services site.

[200] "Commissioning" is the systematic process of ensuring, through documented verification, that the complex array of equipment providing heating, cooling, ventilation, lighting, and other amenities in buildings works together effectively and efficiently. Existing buildings commissioned before are "recommissioned"; existing buildings not commissioned before are "retro-commissioned."

Montana Power Company, NCAT and the County of Butte-Silver Bow) are working together on this project

4.3.3.4.3 Contracting for energy services

Most contracting for energy is separated into contracting for energy using equipment and contracting for fuel. ESCOs blur but don't eliminate that line. In practice, people need energy services—so much light, so much heat—and don't think in terms of energy equipment or fuels. In the early days of electric service, Edison sold hours of light and not kWh; however, sales of fuel and equipment have been the standard form of service ever since. Theoretically, energy services could be contracted out the same way accounting and other support services are. A building manager would specify desired levels of service and the energy contractor would determine the most economical combination of utility provider, equipment and support personnel to provide that service. By making reduced energy costs the primary mission of an organization, it would guarantee that attention would be paid to energy use.

Contracting for energy services is a logical but untested extension of the move to deregulate the utility business. It is an idea that has been discussed in other states in the Pacific Northwest region. It probably is best developed in partnership with other states, possibly through the Northwest Energy Alliance.

Conclusion: Continuing the State Buildings Energy Conservation Program and helping local government agencies develop ESCO programs would reduce greenhouse gas emissions and reduce government expenses. DEQ should develop and expand an enhanced energy monitoring program. DEQ should continue to assess and promote the benefits of commissioning of both new and existing buildings. Finally, DEQ should monitor developments in the concept of contracting for energy services.

4.3.3.5 Tax incentives for energy efficiency

Montana currently provides two modest tax incentives for energy efficiency (listed below by statute number). Raising the level of the credits might have a minimal effect on the energy efficiency of buildings in Montana. Based on past experience, it is not likely to significantly increase the rate at which energy efficiency retrofits take place. DEQ does not have an estimate of the amount of energy efficiency that could be obtained by an increase in the credits.

Montana Tax Credits*

15-32-103 Deduction against corporate income for energy-conserving investments. Data on this credit isn't tracked.

15-32-109 Credit on residential income taxes for energy-conserving expenditures. Amount claimed:

	1993	1994	1995	1996	1997
Amount	$149,970	$150,683	$127,015	$123,749	$120,686
# of claims	2,104	2,114	1,894	1,791	1,609

*Information from Montana Department of Revenue (DoR) *Biennial Reports*.

Conclusion: Due to the unknown and presumed minimal effect on energy efficiency that would result from an increase in energy tax credits, such tax credits probably should not be included as one of the first steps in dealing with greenhouse gas emissions in Montana.

4.3.3.6 Consumer protection measures - building codes, inspection, and certification of energy consumption labels for structures

Efforts to reduce electricity demand by investing in the energy efficiency of structures have been plagued by difficulties associated with the separation between the financial interests and risks of the builder and those of the subsequent owner/operator/resident. First, the builder may have a primary interest in minimizing the construction cost and in focusing on measures that improve the appearance and salability of the structure. Efficiency measures add to the construction cost but do not provide immediate benefits; rather, these measures pay for themselves over a prolonged period of energy savings. Second, efficiency investments are hidden within the structure and are not visible to the buyer. A buyer cannot readily verify builder claims about the energy performance to be expected from the building. Lapses in construction practices, such as poor sealing of vapor barriers and heating ducts or gaps in ceiling insulation, may increase energy use but cannot be detected by a buyer once the building shell is completed.

In most consumer markets the consumer is protected by warranty programs and by recourse to the courts. Given the extended lifetime of buildings, the lag before failures may become known, and the likelihood that they may never be identified, governments have tried to provide additional certainty to consumers through energy building codes, inspection and certification. In Montana, the 1993 Model Energy Code (MEC) is included within the uniform building code.

Because coverage of the code is limited, the benefits to consumers have been limited. Within larger cities and towns, code enforcement falls under local jurisdiction. Areas outside these are under the jurisdiction of the state Building Codes Division. The Montana Legislature limited the purview of the division to four-plex units and above, except in the case of electrical inspections. Single-family houses, duplexes and triplexes outside of the jurisdictions of localities that have chosen to enforce codes themselves are not inspected for compliance with energy codes. (Manufactured houses must comply with federally enforced energy codes.) Instead, builders self-certify that they have complied with the code.

A previous survey, conducted by DEQ in 1996, indicated high compliance with the Model Energy Code within the jurisdictions of most localities that have taken on code enforcement. However, the survey found that approximately 60 percent of the new homes built in 1995 had been constructed outside areas where the energy code is enforced. DEQ has found that homes constructed in self-certification areas can have lesser R-values on crawlspace walls or floors and basement walls than allowed under the Model Energy Code. Window U-values have also been found to be below code in some new homes. To address these shortcomings, DEQ is partnering with the Montana Building Industries Association, investor-owned utilities and rural electric cooperatives to provide training and technical assistance to builders, owner-builders and subcontractors on energy efficient construction techniques. Voluntary federal programs, such as EPA's Energy Star Building Program, provide additional opportunities to provide training to the building industry

Given current prices for energy, and the absence in many cases of strictly enforced building regulations, builders have little incentive to market high efficiency structures or retrofits. At present, the most viable option is for consumers to evaluate their own buildings, using local energy efficiency companies or analytical tools like the Lawrence Berkeley National Laboratory's Home Energy Saver. In the future, as the implications of utility restructuring work themselves out, there should be more companies offering to certify to building owners that they received what they paid for from the builder and from the code inspection.

Conclusion: DEQ should continue work to increase awareness of energy efficiency features and construction practices among builders and consumers.

4.3.3.7 Efficient pricing and billing

One of the barriers to widespread energy efficiency investments is the difficulty consumers have in knowing how much energy and money those investments will save. Further, utilities have had little incentive to promote efficiency for fear that the revenue losses caused by increased efficiency would be greater than the cost reductions they would see due to lower demands. The net effect on utilities was to make them very reluctant partners in energy efficiency.

A variety of solutions were proposed over the past 10 or 15 years, most notably efforts to decouple profits and kWh sales by institutionalizing rates that adjust for net revenue losses due to energy efficiency investments. Despite these efforts utilities in Montana never treated energy efficiency programs as potential profit centers.

Montana Power's sale of its generating assets and concurrent decision not to participate in power marketing in Montana eliminates one of the impediments to energy efficiency in the state. MPC as a distribution utility will not lose power sales as a result of efficiency investments. However, if any utility recovers its transmission and distribution costs through per-kWh charges, the disincentive to efficiency will remain. This is because transmission and distribution (t&d) costs are only weakly related to energy usage. Rather they are mostly a function of demand (peak kW loads) that determine the capacity needed on the t&d systems. Since residential and small commercial peak loads are neither metered nor billed, utilities recover their costs from these customers by monthly fixed charges and by per-kWh charges. When customers conserve energy and purchase less, the utility's revenues decline. Utility costs also decline, but that decline is mainly in energy supply costs. There may be a shortfall in t&d revenues.

The solution to this problem is to either install meters that can measure loads at the time of peak system demands, or to recover t&d costs as part of monthly fixed charges. There may be a move to time-of-day meters due to competition and the desire of competitors to take advantage of rate disparities around the clock. However, should the distribution utilities remain the sole suppliers of meters and metering and billing functions, market movement toward more advanced metering would be inhibited. As for the other alternative, shifting t&d costs to the monthly fixed charge portion of the bill, the PSC has been reluctant in the past to increase the monthly fixed charge. The Commission has indicated it will open a docket on opening metering and billing to competition but so far has not taken any action. The issue of t&d pricing has not thus far been a major focus of attention.

Conclusion: DEQ should continue to monitor the progress of restructuring with regard to competition in metering and billing. DEQ should urge the adoption of energy service rates that are independent of energy usage and that do not create utility disincentives to conservation.

4.3.3.8 Carbon savings from energy efficiency

Reducing the demand for electricity in Montana will reduce the generation of electricity. The impact of reduced power demand on the emission of carbon dioxide is less clear. In an interconnected grid the generating resources whose operation will be curtailed will tend to be those with the highest operating costs at the moment, given transmission system limitations. Those generally will not be located in Montana. They generally will not be the plants with the highest CO_2 emissions/kWh. Coal-fired plants are relatively cheap to operate and relatively difficult to power up and down quickly. They tend to be base-loaded, to run continuously. In the Western Interconnection, which includes western United States, western Canada and northwestern Mexico, the marginal generating plants are typically gas-fired simple cycle turbines or gas-fired steam boilers in California. These plants produce about half as much CO_2 per kWh as produced by the Colstrip plants. However, because of constraints inherent in any electrical transmission grid, these highest-marginal-cost plants in the western grid may not be the ones curtailed should there be a load reduction in Montana.

Preliminary modeling studies performed by the Northwest Power Planning Council indicate that an across-the-board 100 aMW[201] reduction in Montana load would result in less power being needed from a large number of different plants around the western United States over the course of the year.[202] The plants with the 10 largest reductions account for about 30 percent of the 100 aMW reduction; 190 plants account for 99 percent of the total. The largest declines are 6.6 aMW at the natural gas-fueled Beaver combined cycle plant in Oregon, a 4.9 aMW decline at northern California cogeneration plants (a composite, for modeling purposes, of over 100 separate plants, mostly fueled by natural gas); 4.4 aMW at the Boardman coal plant in Oregon; and 3.7 aMW at the Moss Landing plant in California (natural gas). That so many plants are affected probably is due to constraints on the transmission system varying widely over the course of the year.[203] These constraints can, possibly on an hour to hour basis, change which is the most expensive plant that should be curtailed if Montana loads are reduced. DEQ was not able to make an estimate of the total reduced CO_2 emissions at all these plants.

Conclusion: An analysis of the effect of energy efficiency programs on carbon dioxide emissions on a state-by-state basis is needed if these programs are to be expanded as part of a greenhouse gas action program. This analysis should determine patterns of constraints at different seasons and times of day, and determine the likely effect of energy efficiency with different daily and seasonal profiles of demand reduction.

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[201] Average Megawatt (aMW), 1,000 kilowatt-hours every hour over the course of the year.

[202] Jeff King, Northwest Power Planning Council, personal communications with Larry Nordell, DEQ, July 1999.

[203] The biggest variation is between winter, when power is shipped from California north to meet heating loads in the Pacific Northwest, and summer, when power is shipped south to meet cooling loads there.

4.4 Appendix: Changing structure of the utility industry

To understand why some solutions to reduce greenhouse gas emissions are better or more plausible than others, one needs to know how the utility industry has evolved nationally and in Montana. The electric utility industry has been composed largely of vertically integrated firms with local service monopolies. These firms owned their own generating plants (and in some cases, the fuel supply to run them), transmission and distribution networks to deliver the power, metering equipment, and the right to serve all customers within their allotted service area.

Most of the initial growth before the Second World War was in the more densely populated parts of the country, as investor-owned utilities aggressively expanded their networks and signed up customers. Rural areas often were bypassed until the formation of rural electric cooperatives enabled the expansion of service, with the help of government financial assistance and favorable tax treatment. A third segment of the industry consists of municipal power departments and Public Utility Districts, although these were never a significant portion of the industry in Montana.

4.4.1 Traditional regulatory structure

For most of this century private (investor-owned) utilities have been subject to regulation. Retail rates and earnings were regulated by state commissions and wholesale transactions were regulated at the federal level by the Federal Energy Regulatory Commission (FERC, formerly the Federal Power Commission—FPC). Utilities were granted a monopoly within a defined service territory, and regulation was designed to prevent the abuse of monopoly power. Rates were set to recover costs plus an allowed return on prudent investment. In contrast, most cooperative and municipal or public agency utilities have not been regulated by state or local government regulatory bodies.

4.4.2 Environmental regulation in the 1970s and 1980s

Comprehensive environmental regulation of utilities began with the passage of the National Environmental Policy Act (NEPA) in 1969. NEPA required government agencies to consider environmental impacts in making decisions. In the western United States today, it is a rare transmission line, power plant or coal mine that does not need a federal permit or a grant of permission to use or cross federal land. Montana passed its own legislation, the Montana Environmental Policy Act (MEPA), in 1971. The passage of the federal Clean Air Act (CAA) in 1970 lent extra weight to NEPA and MEPA. The CAA required utilities and others to reduce the amount of sulfur dioxide, oxides of nitrogen (NO_X), hydrocarbons and particulates that they put in the air from any plants built after the act was passed.

NEPA, and the state laws such as MEPA that followed it, required an analysis of the environmental consequences of a proposed facility and an evaluation of alternatives to that facility. Utility staff, regulators, and environmental intervenors eventually concluded that a thorough comparison of all alternatives should be made prior to a utility decision to even propose a new generating plant. This process became known as Integrated Resource Planning (IRP, also called Least Cost Planning).

IRP aimed to create investment plans for meeting electricity demand, plans that had a reasonable balance of costs and risks both financial and environmental. IRP was widely implemented as a collaborative planning process, which tended to lend political and technical credence to the results. To conduct IRP, utility staffs would project demand growth and evaluate the costs and risks of alternative ways of providing the needed power. These alternatives included a wide range of fuels, technologies and locations, as well as energy efficiency, to match resources and loads over a defined time period.

Although CO_2 was not generally a factor in IRP analyses, the analytical methods were capable of including it. For instance, preliminary efforts by Montana Power to evaluate carbon taxes on resource choice showed that taxes had very little impact on the choice of the next generating resource.[204] The resource of choice, given current and expected future prices and other environmental regulations, remained natural-gas-fired combined cycle turbines. Because these turbines already are lower CO_2 emitters than most other feasible generating options, a carbon tax was predicted to have little impact on the type of technology used in new plants acquired by a regulated utility.

4.4.3 Utility energy efficiency programs

Many state utility commissions, especially those supporting IRP, required utilities to consider the acquisition of energy efficiency savings as an alternative to the construction of new generating facilities. Utilities, including Montana's large privately owned utilities, developed programs for evaluating energy efficiency and encouraging its implementation by their customers. Utilities often referred to these as demand side management (DSM) programs, emphasizing their nature as alternatives to supply side projects of building more generating facilities. These programs resulted in the acquisition of significant amounts of energy efficiency improvements. For instance, in the Pacific Northwest region, which includes western Montana, over 1400 aMW of efficiency improvements had been made as of 1997, the most recent year for which estimates are available. This is more than the output of Colstrip 3 and 4, and equal to approximately 8 percent of sales in the region that year.[205]

4.4.4 Deregulation, functional separation and divestiture

The vertically integrated structure of the electricity industry began to unravel with the passage of the federal Public Utilities Regulatory Policy Act of 1978 (PURPA). Before the passage of PURPA, independent power producers were at the mercy of the utilities controlling the transmission system. The only potential purchaser was the local utility, which could set prices and conditions at will or simply refuse to connect. PURPA created an independent power industry by requiring utilities to interconnect with and to purchase power from qualifying facilities (QF), which were small power producers and cogenerators. Purchase prices were set by the states' public service commissions to reflect the costs avoided by the utilities by their receiving power from QFs. In the early years of PURPA some states set buyback rates at high levels, hoping to encourage small renewable energy projects. This didn't always work as intended. In California, for example, a flood of large natural gas cogenerators rushed to sign

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[204] Montana Power Company. *1995 Electric Integrated Least Cost Resource Plan*. Butte, MT, March 1995.

[205] Northwest Power Planning Council. *Nutrack 98*. (forthcoming)

long term contracts for the sale of power. Eventually, avoided costs were allowed to decline to reflect a falling need for power.

The independent power industry emerged from the PURPA experience as a strong and vigorous segment of the wholesale power market. Nonetheless, independent power producers, along with the increasingly important power marketers, often found themselves blocked from access to buyers through the transmission systems of utilities competing for those same markets. This eventually led FERC to issue Order 888 mandating the opening of the transmission grid. Order 888 directed transmission owners to functionally separate their transmission operations from their power marketing operations. Further, transmission owners had to offer access to others —utilities as well as independent power producers and power marketers—under the same terms and conditions offered to their own power marketers.

The rise of independent power producers and marketers was accompanied by an increased reliance on wholesale transactions by utilities for their own needs. These developments led to general recognition that power supply is not a monopoly function, and that the power supply portion of the industry could be deregulated if consumers could be protected from market power abuse. At the same time, prices in the wholesale market tend to reflect marginal costs,[206] in many cases considerably lower than the average costs that utilities had been allowed to charge their retail customers. The rising prominence of wholesale competition led large customers, at first mainly large industrial power users, to seek direct access to the wholesale market and bypass their traditional utility supplier. Utilities became vulnerable to the loss of significant portions of their load and feared they would lose their ability to recover the lost revenues from the remaining customers without driving still more of them to seek outside supply.

Not surprisingly, then, the initial impetus for restructuring the industry came from the utilities themselves, seeking to avoid being stuck with stranded costs. In Montana the first draft of restructuring legislation was prepared by the Montana Power Company. The bill that ultimately was passed by the 1997 Montana legislature was designed to ensure that any above market costs not recoverable in a competitive environment could be collected as non-bypassable "transition charges" from retail customers. The bill reflected input from other utilities, customers, and other interested parties. It required utilities to functionally separate their power, transmission, distribution, retail marketing and metering and billing services. The bill applied to all utilities regulated by the Montana Public Service Commission, and to those rural electric cooperatives that intended to compete for markets outside their service territories. Cooperatives that opt out of participation in restructuring were exempt from the bill's requirements.

Montana Power, which serves approximately 50 percent of Montana's retail load, expects to complete sale of virtually all its generating plants to a subsidiary of the Pennsylvania Power & Light Company late in 1999.[207] PacifiCorp, which formerly served around 8 percent of Montana

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[206] Marginal costs are the costs of producing the last kWh needed. Marginal costs in the short term reflect the operating costs of the cheapest plant available to produce that last kWh, and in the long term, the costs of building a new facility to produce that last kWh.

[207] MPC will retain the Milltown dam (3 MW nameplate capacity) because it is part of a Superfund site. Of MPC's partners in Colstrip, Portland General Electric and Puget Sound Power and Light also are selling out to PP&L. PacifiCorp and WWP will retain their shares, but PP&L will hold controlling interest.

loads, has sold its Montana service territory to the Flathead Electric Cooperative (which by the purchase quadrupled in size from 12,000 to 48,000 customers). No PacifiCorp generating facilities were part of the sale. The third jurisdictional utility covered by the restructuring bill, Montana-Dakota Utilities, was given an extended period to comply, and thus far MDU remains vertically integrated. MDU supplies about 4 percent of Montana electricity consumption.

Soon, most Montana customers will be able to choose their power supplier. They will get the power delivered over transmission and distribution networks that remain regulated, but power costs will be determined by the forces of supply and demand, subject to the ability of regulators to constrain market power and to maintain healthy and vigorous competition. These changes in industry structure affect the ability of state regulators to gain compliance with greenhouse gas reduction measures. The effectiveness of old tools, such as PURPA, guaranteed recovery in rates of energy efficiency costs, IRP and even collaborative planning processes, is significantly diminished. In a competitive market, generators are unlikely to recover the cost of reducing greenhouse emissions unless all suppliers in the industry are required to do so. Voluntary compliance with costly control strategies is extremely unlikely.

CHAPTER 5: NATURAL GAS

5.1 Introduction

Natural gas is the choice among fossil fuels for reducing emissions of both greenhouse gases and pollutants currently regulated under the federal Clean Air Act (CAA).[208] The combustion of natural gas produces less carbon dioxide (CO_2) and regulated pollutants per unit of energy than any other common fossil fuel.[209] For uses like space heat, these emissions can be substantially less than other fossil fuels because of differences in the conversion efficiency of the technologies used. Electric baseboard heat from coal-fired electricity causes almost 5 times as much CO_2 as heat from a natural gas furnace. Natural gas combustion accounts for less than 10 percent of all inventoried greenhouse gas emissions in Montana.[210]

Commercially available natural gas is usually at least 80 percent methane (and typically much more) with impurities, mostly CO_2 in combination with very small quantities of other hydrocarbons and inert gases. Depending on conditions, combustion of natural gas produces CO_2, water vapor, CO, NO_x, and carbon particulates. The last three of these products are "criteria pollutants," substances regulated under the CAA. With ideal combustion conditions, more CO_2 and water vapor and less regulated substances are emitted.

Although not the cheapest raw fuel per unit of heat content, natural gas often is the cheapest fuel to use. It burns cleaner, with lower emission mitigation costs than most alternatives, and natural gas facilities tend to be less expensive to build. Over the next decades, the price and convenience of natural gas make it the likely choice for new facilities and retrofits in many

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[208] Natural gas also reduces dependence on imported fuel. In 1998, 15 percent of the natural gas used in the U.S. was imported, versus 60 percent of the petroleum. (U.S. Energy Information Administration. *EIA Annual Energy Review 1998.)*

[209] Natural gas produces 117 pounds of CO_2 per million British thermal units (mmBtu), while fuel oil produces 38 percent more and coal produces 82 percent more for the same amount of energy.

[210] Including all uses and estimated quantities of methane lost during production.

applications. While this is desirable because natural gas burns cleaner than other fuels, significant quantities of greenhouse gases will be released in the production, delivery and combustion of natural gas. However, these will be more than offset by reductions in emissions from other fuels, especially coal, brought about by switching to natural gas. Fugitive methane emissions from natural gas and petroleum production and distribution have been declining, partly due to the restructuring of the industry.

Summary of conclusions: While the efficiency of natural gas use can always be improved, many of the strategies to improve that efficiency are simply more modest versions of what could be done to improve the efficiency of electricity use. Concentrating on removing distortions in energy markets that impede the efficient use of natural gas, especially in the electricity sector, would be an effective way to reduce greenhouse gas emissions.

5.2 Natural gas use in Montana

In 1997, Montanans consumed 55,791,534 mmBtu[211] of natural gas. Residential customers used 39 percent, while the commercial and industrial customers accounted for 26 percent and 35 percent of the total. Nearly all residential and commercial consumption was for space and water heating. Industrial customers used natural gas to fuel furnaces and boilers for manufacturing processes, as a chemical feedstock,[212] and for facility space heating. Electric utility generators used a small quantity of natural gas to start coal boilers, and a small quantity was used in small generating plants, but no large-scale natural gas-fired electric generating plants were operating in Montana. Very little natural gas was used as vehicle fuel in Montana.

Overall, natural gas consumption appears to be increasing steadily in all sectors. Throughout the United States, the construction of new natural gas-fired electric generating plants, a result of electric deregulation, is creating large demands for natural gas that did not exist a decade ago.[213] Meanwhile, pipeline and distribution systems are expanding into new areas, creating more demand for the commodity as old and new buildings are connected to these systems.[214] Natural gas remains relatively inexpensive in most cases compared to the common heating fuel alternatives available in Montana.[215]

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[211] Traditionally, natural gas quantities have been expressed in terms of volume (e.g., thousand cubic feet—mcf—or million cubic feet—mmcf). They are now commonly expressed in terms of energy content (e.g., in million British thermal units—mmBtu). The volumetric equivalent of the 55,791,534 mmBtu consumed in 1997 was 54,114 mmcf.

[212] Petroleum refiners use natural gas as a source of hydrogen for refining processes.

[213] For instance, 88 percent of new electric generating plants expected to come on line in the U.S. between 1998 and 2007 are expected to be natural gas-fired. U.S. Energy Information Administration. *Natural Gas 1998: Issues and Trends, 1999*. p.58.

[214] In some areas, particularly the Pacific Northwest (PNW), cheap and abundant electricity from hydroelectric projects previously made natural gas less attractive for heating. As electric deregulation unfolds and local markets melt into larger regional markets, the price of electricity in areas like the PNW will probably increase to approach prices in surrounding regions, particularly California and the Sunbelt. Consequently, demand for natural gas will probably grow in areas where low-priced electricity has been the primary heating fuel.

[215] In 1996, roughly 46 percent of the capacity to generate electricity in Montana was coal-fired, 52 percent was hydro-powered, and only 2 percent was natural gas-fired. In 1996, 47 percent of the electricity generated in

Montana's residential and commercial consumption each peaked in the early 1970s (see Figure 5.1). Consumption steadily decreased through the late 1980s, and then increased through the present time. Residential consumption peaked at over 25,000 million cubic feet (mmcf) in 1971, decreased to a 30-year low of 15,000 mmcf in 1987, and rose in 1997 to 21,000 mmcf. Commercial consumption peaked at just over 19,000 mmcf in 1972, then steadily decreased to about 11,000 mmcf in 1987. By 1997, commercial consumption had risen again to almost 14,000 mmcf.

Montana came from coal-fired plants, 52.8 percent came from hydroelectric dams, and only 0.1 percent came from natural gas-fired plants. (See U.S. Energy Information Administration *State Profile* for Montana.)

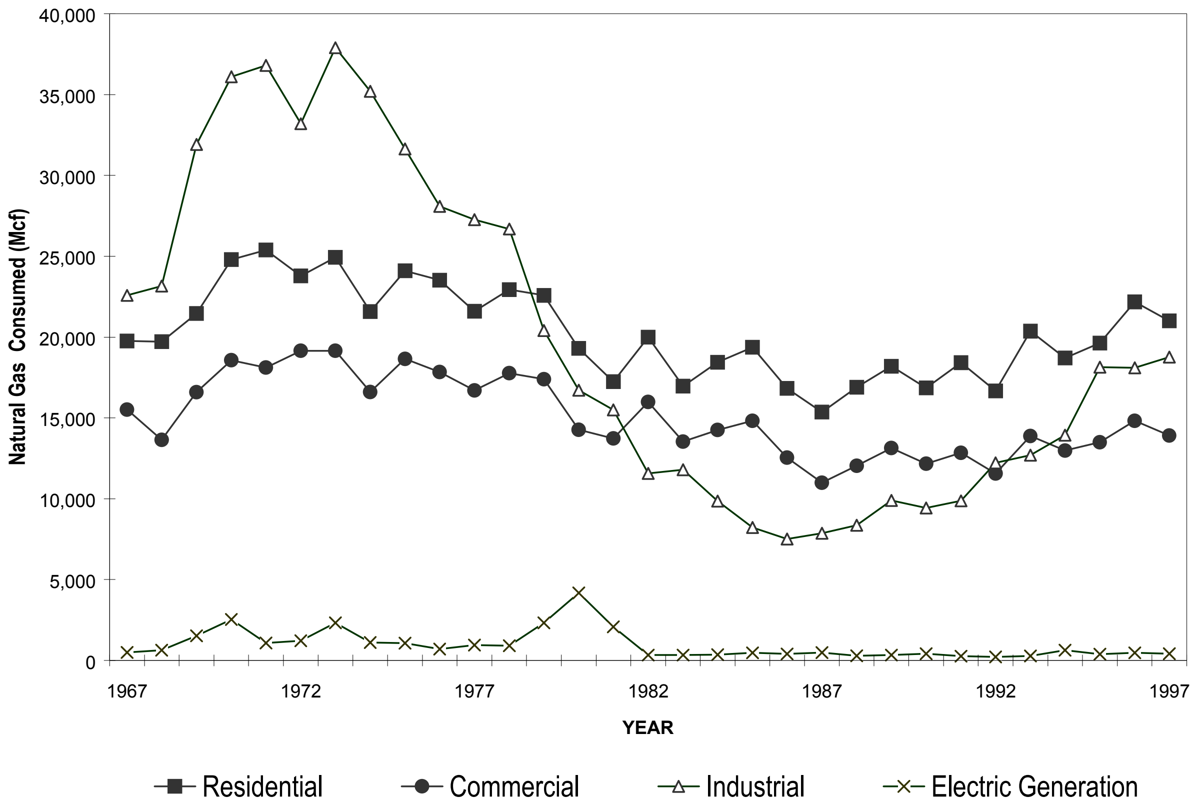

Figure 5.1: Historical Natural Gas Consumption, By Sector (1967 – 1997)

Most variation in residential and commercial consumption over the past 30 years can be explained as responses to fluctuations in natural gas price and the weather. Over the long term, commercial and residential consumption trends seem primarily to follow trends in prices (see Figure 5.2). Consumption peaked in the early 1970s, when the "real price"[216] of natural gas was at a 30-year low. Consumption then dropped in the late 1980s when real price reached 30-year highs. Climatic variations (expressed as changes in annual "heating degree days"[217]) appear to account for sharp year-to-year fluctuations in residential and commercial consumption (see Figure 5.3). For instance, the large difference in the volumes non-industrial customers used in 1985 and 1987 correspond closely with the respective difference in heating degree days.

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[216] The "real price" of a good or service is the price in dollars of constant value, after removing the effects of inflation or deflation from annual changes in the purchasing power of the dollar.

[217] Heating degree days (HTDG) are used as an indicator of the amount of energy needed for space heating. HTDG are calculated by subtracting the crude average daily temperature from 65°F. The crude average is calculated by dividing the sum of the daily high and low temperatures by two {(Tmax +Tmin)/2}. For example, for a day with a high temperature of 30°F and a low temperature of 0°F, the HTDG is 50 (from the following calculation: 65-{(30-0)/2} = 65-15= 50). The annual HTDG is the sum of the daily HTDG in a year.

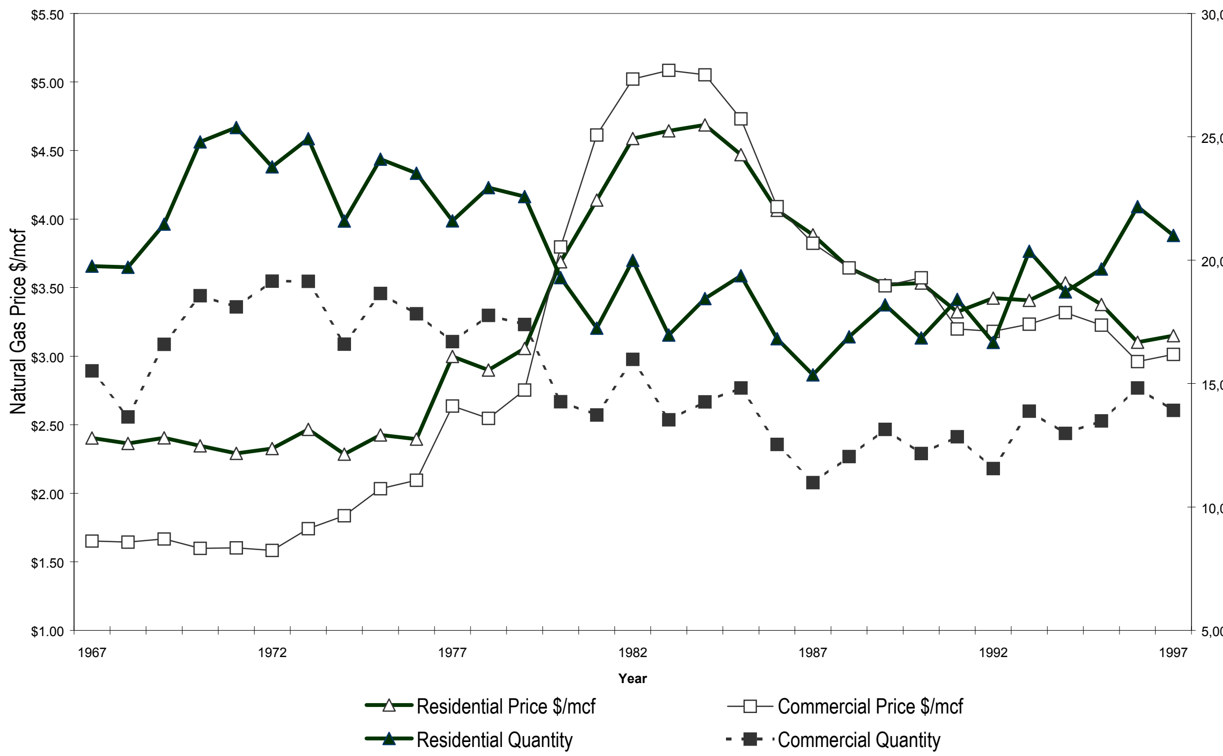

Figure 5.2: Residential and Commercial Natural Gas Consumption and Price (1967 – 1997)

As expected, Montana's non-industrial consumption is positively correlated with population. Population growth appears to account for the general long-term growth in residential consumption since the late 1980s, as more dwellings and commercial buildings were built to accommodate more people.[218]

Industrial consumption has displayed a similar pattern of hills and valleys, though the variation has been more dramatic than with non-industrial customers. In 1973, industrial consumption was up to 38,000 mmcf, then hit a 30-year low of 7,500 mmcf in 1986. Industrial consumption then more than doubled to over 18,000 mmcf in 1997.

[218] Another trend that could account for increasing natural gas consumption through time is increasing building size. However, DEQ currently has no data regarding the size of new buildings through the years, and at present cannot break out the magnitude of the impact of that trend.

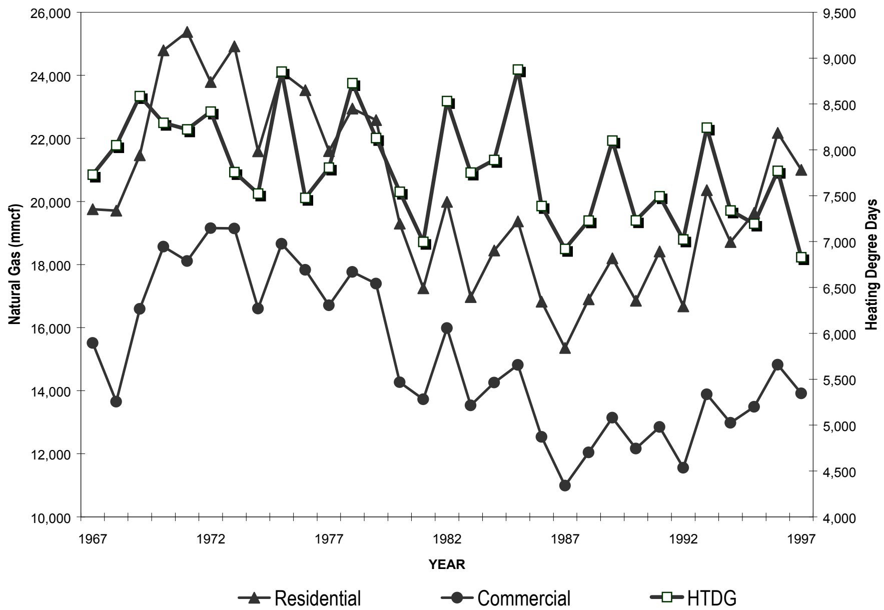

Figure 5.3: Residential and Commercial Natural Gas Consumption and Heating Degree Days (1967 – 1997)

Through the last three decades, industrial consumption has been sharply affected by the energy intensity of the dominant industries operating in the state at any particular time. During the 1970s and 1980s, industrial consumption of natural gas strongly correlated with production from the Anaconda Company's smelters, which accounted for the preponderance of industrial use. Industrial gas consumption dropped to its 30-year low three years after copper smelting ended.[219] Since then, industrial consumption has grown as other industries increased production and/or switched to natural gas. After 1986, industrial consumption grew by over 50 percent every five years – increasing from 7,800 mmcf in 1987 to 12,200 mmcf in 1992, then to 18,800 mmcf in 1997. Still, 1997 industrial consumption was less than half of peak consumption in the copper smelting days. Currently, the largest industrial natural gas consumers are petroleum refineries, cement plants and wood product manufacturers.

5.3 The natural gas market

5.3.1 Transmission and distribution

The market for natural gas operates at local, regional and national levels. Many factors shape local markets for natural gas. These include climate, proximity to gas fields, the historical buildup of distribution and transmission pipeline infrastructure, and the availability of economical alternative fuels.

Montana lies among major northern Rocky Mountain gas production areas, so the fuel is plentiful and transportation cost is low. Montanans inherit an extensive gas pipeline system,

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[219] Price also matters. Industrial natural gas consumption began to decrease significantly when the real price of natural gas started to increase around 1973. The coefficients for natural gas price and copper output were both significant in DEQ's regression analysis of historical industrial consumption.

making the fuel readily available without the need for considerable new investment.[220] Montana Power Company originally developed its system in the first half of the 20th century, primarily to serve metal smelters in western Montana. The Montana-Dakota Utilities developed its system to open markets for gas produced by oil fields in southeastern Montana.

Demand for natural gas fluctuates greatly between winter and summer, while natural gas wells operate best when they can produce at relatively steady rates. To increase the volume of natural gas available for ready delivery during winter, natural gas is injected into storage during warmer weather. Storage facilities are typically located in underground reservoirs such as played-out gas wells, salt caverns (old mines), or certain aquifers. Storage affords marketers greater supply flexibility, while allowing producing wells to operate more steadily than they would without a place to ship their gas during periods of slack consumer demand.

Natural gas delivered from storage facilities competes with gas delivered directly from wells. Thus, during periods of high demand, market price increases are dampened as storage gas increases the volume available to the market. Likewise, when large quantities of gas are in storage toward the end of a heating season, prices tend to fall as marketers empty storage gas into the market to avoid the cost of holding it through the summer. Ideally, marketers fill storage during periods of relatively slack demand and low prices, in hopes of selling the gas at higher prices to recover storage service fees. At any given time, the market price of natural gas responds to the interplay of demand to fill storage and the timing of consumer demand.

Transmission and distribution costs usually account for more than half the delivered cost of natural gas. Since fixed costs are a large component of the cost of natural gas transmission, larger volumes of gas moving through pipelines reduce the unit cost of transmission and distribution. Rising demand can eventually lead to localized supply bottlenecks and pipeline capacity constraints that limit natural gas availability. Pipeline companies then invest to increase capacity, either by adding compressors on existing lines or by installing more pipe. Such new additions often increase transmission rates. The expansion of both transmission and distribution lines are constrained by the numbers of customers they potentially serve. Small towns are unlikely to have access to natural gas unless they are located on the transmission route between source areas and larger population centers. Similarly, low density developments around major cities are less likely to have natural gas service than more densely developed the areas within the cities.

5.3.2 Natural gas regulation and deregulation

Federal regulation of natural gas utilities began with the passage of the Natural Gas Act (NGA) in 1938. The NGA placed sales for interstate resale, interstate transportation, and facilities used for sales and transportation under the regulatory jurisdiction of the Federal Power Commission (FPC). Eventually, the FPC's regulatory reach covered pipeline affiliates[221] and independent producers.[222] While federal regulation corrected some monopoly abuses in the industry, it had

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[220] In many areas of the country, such as parts of the Pacific Northwest and New England, natural gas transmission and distribution systems are poorly developed beyond those in a few large population centers.

[221] Following passage of the Public Utility Holding Company Act (PUHCA) (1935) and the US Supreme Court's decision in Interstate Natural Gas Co. Vs FPC 331 U.S. 682 (1947).

[222] Following the U.S. Supreme Court's decision in Phillips Petroleum Co. Vs Wisconsin 347 U.S.672 (1954).

unintended effects in the independent production sector. By the 1970s, regulatory policies, including "vintage pricing," and "area rates" that created regional price ceilings,[223] had created huge market distortions that inhibited both the efficient production and use of natural gas. Other policies, including the federal Power Plant Fuel Use Act, and local moratoriums on gas line extensions, inhibited expanded use of natural gas.

The U.S. Congress started down the path to natural gas deregulation by passing the Natural Gas Policy Act (NGPA) in 1978. The NGPA removed price controls on gas produced from "new wells," and initiated the eventual restructuring of the utility industry. Congress ended federal regulation of all wellhead prices in 1989, with the passage of the Natural Gas Wellhead Decontrol Act.

In Montana, the real price of natural gas to end-use customers reached historical highs in the early 1980s. As wellhead deregulation continued through the late 1980s into the early 1990s, a legacy of prescriptive energy policies, combined with uneven deregulation across all sectors of the energy industry, created a natural gas surplus. Prices plunged, and instability rocked all sectors of the natural gas industry. Like other industries at that time, most natural gas companies restructured their businesses in the early 1990s.

The early 1990s brought fundamental changes in Montana's natural gas industry that will continue to unfold into the next decade. Traditionally, monopoly utilities have been the primary natural gas resellers, and have received state-regulated rates based on their costs of acquiring supplies. However, beginning in 1991, Montana Power Company (MPC) allowed its largest customers to purchase natural gas from non-utility suppliers. MPC developed plans to transfer utility-owned gas production assets to an unregulated affiliate, and petitioned the Montana Public Service Commission for recovery from ratepayers of what it termed "stranded costs."[224] Legislation passed in 1997 established the guidelines for restructuring the natural gas industry but did not force utilities to restructure. Those utilities that voluntarily chose to restructure had to "unbundle" their utility rates by breaking out commodity transportation and distribution services, ending utility commodity sales, and opening their systems to competitive natural gas marketers. The legislation allowed a parent company to recover "transition" costs when utilities disposed of regulated supply assets.

Montana's restructured utilities now allow end users to purchase their supplies from competitive gas marketers.[225] Some of Montana's largest industrial, commercial and institutional customers already do so.[226] Generally, these customers have paid less under deregulation than they would have for traditional "bundled" natural gas service, purchased directly from utilities.

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[223] Area rates arose in part because the FPC could not handle the case load when it tried to regulate independent producers' activities.

[224] "Stranded costs" are costs that were incurred when the utility was regulated, but that in a deregulated market can no longer be passed on to consumers.

[225] Deregulation only affects the structure of sales of the natural gas commodity. The transmission and distribution of natural gas are still regulated by state and federal agencies.

[226] Montana Power Company and Great Falls Gas already allow large customers to procure gas supplies from competitive marketers, and are currently allowing smaller customers do so in pilot projects.

5.4 Factors driving future growth in natural gas use

In the future, consumption of natural gas probably will continue to rise steadily (see Figure 5.4). DEQ expects commercial consumption to remain at about 15,000 mmcf annually through 2010, about 1,000 mmcf above the 1997 level.[227] Residential consumption is expected to steadily increase from its 1997 level of 21,000 mmcf to almost 25,000 mmcf in 2010, an increase of about 400 mmcf each year.

[227] DEQ derived consumption forecasts through regression analysis using 30 years of historical consumption, price, climate and census data (from 1967 to 1997), EIA price forecasts, and U.S. Census population forecasts.

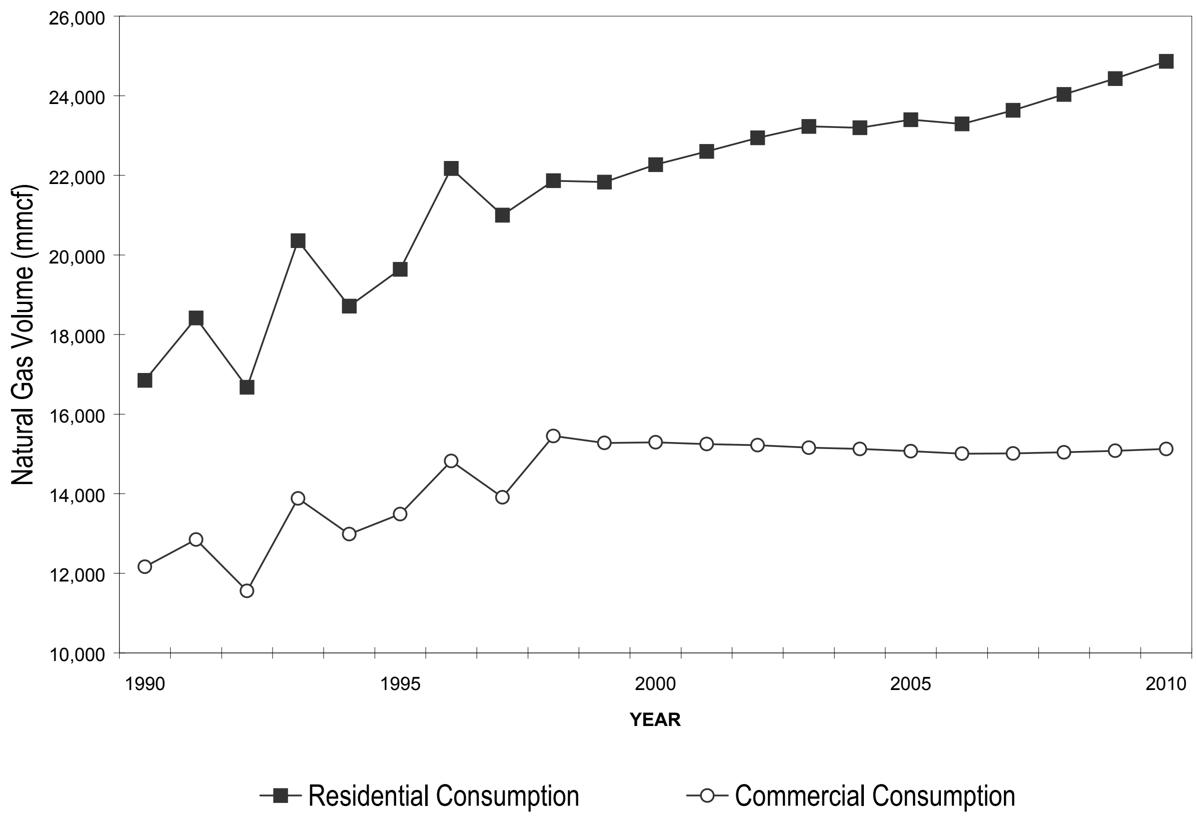

Figure 5.4: Actual (1990-1997) and Forecast (1998 – 2010) Residential and Commercial Natural Gas Consumption

Industrial consumption will probably continue to increase, as manufacturers switch from more expensive (and dirtier) fuels to cleaner burning natural gas. DEQ did not forecast industrial consumption because this consumption is controlled by complex factors that are not readily anticipated. The historical analysis showed that industrial consumption has been strongly dependent upon the energy intensity and output of the particular industries operating in Montana at any given time, and on the prices of alternative fuels such as coal. For instance, as copper smelting ended in Montana, industrial gas consumption plummeted, and has not since reached half the levels it attained during the 1970s. It is impossible to predict which industries will be operating in Montana in the future, how energy intense they will be, or what their output rates will be. However, there is no reason to expect that the recent trend of industrial consumption increasing roughly 50 percent every five years will continue.

Clearly, the most important factor driving natural gas consumption growth in Montana is its relatively low price. Natural gas is currently the cheapest fossil fuel for non-industrial space and water heating applications, and the lowest cost fuel for many industrial applications.[228] For

[228] Though coal might cost about half as much per Btu equivalent, the total cost of using coal, including handling and emission mitigation costs, can exceed the cost of using natural gas for many industrial applications.

instance, a typical bill for households using electric heat is about $1000 per year, compared to $450 for natural gas.[229]

As long as this price advantage exists, natural gas will be the most attractive fuel for many uses. The real price of natural gas is expected to stay relatively constant through 2010, and to remain low relative to other fuels. This price advantage will probably increase demand for natural gas.[230] The transmission and distribution infrastructure will continue to gradually expand around urban areas and pipeline corridors, making the fuel an alternative for electric and propane heating customers in those areas.

Most new residential and commercial buildings will heat with natural gas wherever it is available, and many existing buildings will convert to natural gas when it becomes available to them. Conversion of propane heating systems to natural gas is simple and quite inexpensive, once buildings are connected to pipelines or local distribution systems. While switching from electric to natural gas heat often requires significant investment, those costs can be recovered quickly due to the magnitude of the savings from using natural gas.

Of the large customers that already purchase their natural gas supplies from marketers, some have responded to the lower prices by increasing their gas consumption, while others have switched from other fuels to natural gas. This has led to greater total consumption of natural gas. Large industrial customers, who use gas for industrial processes and as chemical feedstock, have high price elasticity of demand for natural gas, which means that they can easily adjust how much gas they use when the price changes. Residential and commercial customers, whose use is largely dependant on climatic conditions, have relatively inelastic demand, meaning they cannot readily adjust their consumption in response to price changes.[231] However, when smaller customers are allowed to acquire natural gas in the competitive market, they too will probably increase their consumption should they experience lower prices.[232]

Accordingly, DEQ expects greenhouse gas emissions due to combustion of natural gas to increase in the next decade. However, slower growth of, or reductions in, greenhouse gas

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[229] Electric heat assumptions: An average home uses 16,666 kWh per year at $0.06 per kilowatt-hour; newer homes use about 12,000 kWh and older homes use around 20,000 kWh. Natural gas assumptions: An average home uses 90 mcf per year for heating, at $5.00 per mcf.

[230] U.S. Energy Information Administration estimates that natural gas will be the cheapest fuel available to the residential sector from 1997 through 2010, and will be competitive with all fuels except residual fuel for that period. Annual Energy Outlook 1999 (AEO99). July 1998. Table 18.

[231] For instance, DEQ estimates it would take a price increase of 38 percent to bring about a 10 percent reduction in residential Montana customers' consumption. This suggests that a carbon tax on natural gas would have little direct impact on residential consumption levels, though it should make future investments in efficiency appear more attractive to some customers.

[232] However, small customers might not see the degree of price reductions larger industrial and institutional customers already have obtained. The way markets generally operate, customers with more flexible demand usually get more competitive commodity prices, while customers with less elasticity get less competitive prices. Additionally, price reductions might not occur for smaller customers, because the large numbers of transactions and smaller volumes per customer might increase transaction costs per unit of gas sold enough to offset any benefits from receiving a market price.

emissions from fossil fuel-fired electric generating plants, especially coal-fired plants, would more than offset these emissions.

5.5 Reducing greenhouse gas emissions due to the use of natural gas in Montana

DEQ's analysis suggests that Montana's greenhouse gas emissions from natural gas combustion will increase unless something is done to reduce the demand for natural gas. This means switching to other energy sources or using natural gas more efficiently.

5.5.1 Residential and commercial fuel switching

Fuel switching would probably increase greenhouse gas emissions unless the replacement fuels were renewable, since natural gas already produces the lowest greenhouse gas emissions per unit of energy equivalent of the available fossil fuels. Few satisfactory renewable fuels are available for space heating in Montana.

Wood products are renewable, but they produce other undesirable emissions, unless burned under ideal conditions. Wood products do not work well in heavily populated areas of western Montana, where valleys are particularly susceptible to inversions that trap pollutants. Wood smoke is a significant pollutant in the nine Montana towns that fail to meet National Ambient Air Quality Standards for particulates.

Solar space heating designs can reduce dependence on fossil fuels, but are not suitable for many existing structures. In new construction, solar designs often require significant front-end investments that have long payback periods when compared to the life-cycle cost of fossil fuel heating systems.[233]

The geothermal resource in Montana is limited, both geographically and in terms of available energy, and will probably not become a significant alternative to fossil fuels in the future. Hot springs and hot water wells, though relatively abundant in Montana, are nonetheless limited to a few areas, and only produce enough heat for a few buildings. Ground-source heat pumps (which can both heat and cool a building) are expensive, and might not be cost-effective in parts of Montana that only need air cooling for a few days of the year. Moreover, replacing natural gas systems with electric heat pump systems would produce more greenhouse gas emissions because some of the electricity would come from coal-fired generating plants.

Montana does have significant potential for renewable electric generating capacity. The tremendous wind power resource in the state is almost completely untapped. However, electricity from renewable sources will not sell for less than the market price of electricity, which already is considerably more than the price of natural gas. If marketed as "green power," electricity from renewable resources might sell for a premium above electricity generated with coal (see p.1). Even so, some consumers might choose to heat their homes with green power for

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[233] Unless a building is specifically designed to heat entirely with solar energy alone, the builder must usually install conventional systems for supplemental or primary heat. Since natural gas heating systems are more expensive to install, solar buildings often have electric or wood heating systems, which can produce more undesirable emissions than natural gas systems.

the environmental benefits, especially those individuals who only need supplemental heat for solar-heated buildings.

Conclusion: Encouraging fuel switching by customers using natural gas is unlikely to reduce greenhouse gas emissions.

5.5.2 Increasing efficiency

Under current conditions, the most direct way for Montanans to decrease natural gas-related greenhouse gas emissions is to increase the efficiency with which they use the fuel. In the short run, CO_2 emissions could be reduced by increasing efficiency in the residential and commercial sectors, where smaller facilities use natural gas primarily as seasonal heating fuel. Over the next five to ten years, industrial and institutional facilities with large heating and electrical demands could increase efficiency by adopting technologies that extract heat and electric energy from the natural gas they use. Efforts to increase efficiency in natural gas utilization will dovetail with efforts to increase the efficiency of electricity use.

5.5.2.1 Small furnace combustion efficiency

Private and public organizations have been working to increase water heater, boiler and furnace efficiencies since the energy crises two decades ago. High fuel prices in the 1970s and 1980s, along with the threats of shortages, spurred government initiatives to reduce fossil fuel consumption by increasing fuel-use efficiency. Among these were federally mandated efficiency standards for major household appliances: furnaces, water heaters, clothes washers, refrigerators, freezers and central and room air conditioners. Congress established minimum combustion efficiency standards through the National Appliance Energy Conservation Act of 1987. New natural gas furnaces are required to attain annual fuel utilization efficiency (AFUE) ratings of at least 78 percent and boilers at least 80 percent.

Consumers can now choose from a menu of equipment with various efficiency levels, with a corresponding variety of prices. Most efficiency gains come from relatively simple modifications, such as insulation, flue dampers and intermittent ignition devices[234] that reduce fuel consumption significantly at very little capital cost. The highest efficiency equipment, with AFUEs of over 90 percent, have sealed combustion chambers, condensation technologies that extract heat from water vapor in natural gas combustion exhaust gases, and fan-assisted direct vents that take combustion air from outdoors.

High efficiency fan-assisted direct vent heating equipment provides secondary benefits in the form of enhanced indoor air quality. Natural draft furnaces, boilers, and water heaters can spill exhaust gases (including deadly carbon monoxide) into tight homes, creating health concerns. Unlike natural draft equipment, direct-vent systems do not backdraft, since they use outside air for combustion, and do not create the negative pressures that draw exhaust gases back into

[234] Intermittent ignition devices reduce gas consumption by using an electrostatic spark to ignite the burner when heat is demanded, rather than using a standing pilot light that burns fuel all of the time regardless of demand for heat.

houses.[235] Greater use of high efficiency heating equipment could be spurred by public education about such air quality benefits, particularly for people with sensitive respiratory conditions.

Efficiency standards have increased incrementally over the last 25 years, increasing significantly since the 1970s. As old furnaces and boilers reach the end of their service lives, they are replaced with higher efficiency units, rapidly boosting average system efficiencies. New furnaces operating at over 90 percent AFUE bring the current national average to about 82 percent AFUE. A furnace with 90 percent AFUE produces 13 percent less CO_2 than a furnace with 78 percent AFUE for the same load. Increases in furnace efficiency standards are expected soon, which will raise average efficiency even higher.[236]

Expected efficiency gains as furnaces are replaced will reduce Montana's greenhouse gas emissions from natural gas by several percent. National survey data indicate that over one-third of the main heating systems in western households are over 20 years old.[237] Furnaces in the vast majority of these households operate at less than 78 percent AFUE. These furnaces represent a large potential reduction in greenhouse gas emissions. Rough estimates using national averages suggest that an increase in average furnace efficiency in Montana of 7 to 8 percent would decrease future residential greenhouse gas emissions from natural gas by about 10 percent.[238] However, DEQ lacks specific data about Montana's residential and commercial heating system characteristics, and cannot precisely estimate potential greenhouse gas reductions.

Furnace and boiler efficiency gains have helped reduce fuel consumption, but only properly installed and maintained units operate at rated efficiencies. Often, heating systems are forgotten, only receiving attention when they are clearly broken. Few home and business owners are heating system specialists, nor are they accustomed to paying others for labor intensive maintenance as they might, for instance, for automobiles. One study found that furnace tune-ups reduced fuel consumption by over 10 percent yet cost less than $200 per house, with payback periods of less than 2 years.[239] Lower fuel consumption translates directly into reduced greenhouse gas emissions.

Replacing older but still functioning furnaces could significantly increase system efficiencies and reduce greenhouse gas emissions. While the economic benefits of replacements might pencil out on paper, many consumers are reluctant to replace expensive components until they have run their useful service lives. For instance, one study put the simple payback for an upgrade from a 78 percent AFUE residential furnace to a high efficiency condensing furnace replacement at

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[235] When heating equipment uses indoor air for combustion, the flow of exhaust from the building creates negative pressure. Replacement air moves through openings in the building, or may come back down the flues in the form of backdrafts, which carry exhaust gases back into the building.

[236] Mark Piquette, Intertech Testing Services Program, New York, personal communications with Jeff Blend, DEQ, July 1999.

[237] See U.S. DOE's *Residential Energy Consumption Survey 1997.* Table 3.15a. Space Heating by Census Region.

[238] DEQ's regression analysis, assuming the efficiencies of Montana's residential furnaces are comparable to U.S. averages.

[239] John Proctor and Bobbie Foster, "Low Cost Furnace Efficiency Improvements: 10,000 Furnaces Later," Sun Power Consumer Association, Wheatridge, CO. June 1989.

between 8 to 15 years, too long for many consumers.[240] Though fuel price increases could spur earlier heating plant replacements, many consumers are unlikely to make these improvements without strong economic incentives. Government and private programs that allow homeowners to include efficiency measures in home mortgages could make payback periods less of an issue, as higher mortgage payments would be offset by reduced energy costs and greater comfort.

Conclusion: Continued development of national efficiency standards for heating systems will reduce greenhouse gas emissions, as will encouraging regular maintenance of heating units.

5.5.2.2 Ductwork

Reducing distribution losses in forced air furnace systems could cut greenhouse gas emissions significantly. Leaky, uninsulated ductwork can waste 40 percent of the heat produced by furnaces.[241] A system wasting that much of its heat produces 65 percent more greenhouse gas than it would were it insulated and sealed up. A national survey estimated that nearly 60 percent of all heating systems in the west use natural gas, and nearly 70 percent of those natural gas systems are central warm-air furnaces.[242] Anecdotal information and U.S. Census data indicate that a higher percentage of residential heating systems in Montana use natural gas than in the west as a whole, suggesting that the potential for greenhouse gas reduction is large.

Evidence indicates that ductwork leakage is a large problem in old and new residential buildings. For example, one-third of the new houses examined in one study found mechanical systems that significantly depressurized basements, a condition that can lead to dangerous flue gas backdrafts.[243] In another study, 56 percent of the new homes examined in the four Northwest states had combustion appliance zone pressures worse than -5 Pascal.[244] Recently, DEQ staff, in a test of four homes, found that three had negative pressures of less than -5 Pascal in crawlspaces when furnaces were operating.[245]

The problem is worst in houses with ductwork in unheated, often poorly insulated crawlspaces. Crawl space construction varies around Montana. Bozeman's building code department indicated that 99 percent of new homes have crawlspaces, 80 percent have heating equipment in the crawlspace, and 10 percent have water heaters in the crawlspace. The degree to which

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[240] Simple payback periods are the time it takes to pay for an efficiency improvement with cost savings, and depend upon heating loads and fuel prices. "Space Heating" *Technology Atlas Series, Volume 3*, E Source, Boulder, CO, 1996, page 206.

[241] Ibid., page 201.

[242] U.S. Energy Information Administration. *Residential Energy Consumption Survey 1997*. Table 3.15a. Space Heating by Census Region.

[243] " Shoddy Ductwork Is Commonplace - Dangerous - in New Colorado Homes." *Energy Design Update*, Cutter Information Corp., January 1998. This study found that the basements in 7 of 24 houses tested were at risk of backdrafting because of depressurizing due to duct leaks.

[244] "Pascals" are units of pressure. The air pressure inside a building should not be more than 3 to 5 Pa below the atmospheric pressure outside the building. Brock, David, "A Simple Test Can Spot Carbon Monoxide Danger," *The Northwest Builder*, Iris Communications, Inc. 1996.

[245] Paul Tschida, DEQ, personal communication with Bob Frantz, DEQ, July 1999. Tschida found air pressures of -17, -8, -8, and -4 Pascal in four basements he measured.

ductwork is sealed varies by town, according to a 1999 DEQ survey of 13 of the 48 building code departments in Montana. For instance, the City of Hamilton reported 95 percent of new homes had complete sealing of ductwork, Forsyth reported 50 percent complete sealing, and Bozeman reported 60 percent had no sealing and 40 percent had some sealing.

Ductwork efficiency upgrades are inexpensive and pay for themselves through lower energy bills within several years. A report by the Bonneville Power Administration's Residential Construction Demonstration Program (RCDP) found that ductwork efficiency upgrades that cut heat leakage by more than half in some cases could be installed for an average of $335 per house.[246] Savings in gas bills should make investments like this acceptable to most consumers. DEQ does not know how many Montana households have ductwork heat loss problems.

Conclusion: A comprehensive survey of the Montana housing stock to determine the condition of ductwork sealing and crawlspace insulation would identify where improvements can be marketed. DEQ should educate the public about the costs and benefits of properly sealing ductwork and insulating crawlspaces.

5.5.2.3 Building shell components

Over the last 25 years, changes in building code requirements for minimum building envelope thermal efficiencies have reduced the amount of energy necessary to keep a building warm. In Montana, building envelopes must meet the provisions of the 1993 Model Energy Code. This code was updated in 1995, but will no longer be updated by its sponsoring agency, the International Conference of Building Officials. The Model Energy Code is being replaced by the International Energy Conservation Code, issued by the International Code Council. The first edition of this code was published in 1998. Adopting this code would lead to higher levels of building energy efficiency in the future.

As efficiency standards improve, the energy required to heat residential buildings would continue to gradually decrease. While these standards apply to all houses, they will probably be designed with electrically heated houses in mind, since electric heat is far more expensive than natural gas.

Conclusion: Adopting the International Energy Conservation Code to replace the 1993 Model Energy Code for residential and non-residential buildings would lead to higher levels of energy efficiency and reduced emissions.

5.5.2.4 Market-based efficiency incentives

In tandem with standards, market-based approaches have created incentives for builders to meet, and for consumers to demand, certain levels of energy efficiency. "Market-based" in this case has meant programs that reduce the cost of capital and improve consumer understanding of the product—energy efficiency. Unlike commercial and industrial entities, homeowners often have limited access to capital, and often lack knowledge necessary to invest wisely in energy efficiency measures. Tax incentives also have been offered for energy efficient investments, but

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[246] "RCDP IV Final Report: Improved Air Distribution Systems for Forced-Air Heating," Bonneville Power Administration, 1995.

as discussed in Chapter 4 (p.1), they have not been widely utilized. The maximum credit against state taxes is relatively low, only $150.

HUD standards: The oldest and most widely used market-based approach to energy efficiency is the conditions on mortgage loans established by the U.S. Department of Housing and Urban Development (HUD). HUD's mortgage loans require that eligible homes incorporate, among other things, specific minimum levels of energy efficiency. Conventional loans through banks often include the same condition, to enhance the resale of the house in the future. Builders are not forced to comply with these requirements, but they try to meet them to expand the pool of customers in the market for their products.

Utility Residential Efficiency Programs: For many years, owners of existing homes have gotten information through utility-run residential efficiency programs, such as Montana Power Company's free energy audits. Utility-run residential efficiency programs educated consumers about the condition of their homes, and about the benefits of energy efficiency retrofits. A contractor would analyze a property's utility bills, then visit the home and examine heating equipment, insulation levels, ducting, and venting, and test building envelope air-tightness. The contractor then would make recommendations about how the homeowner could increase efficiency and comfort. A few small efficiency-enhancing devices such as water flow reducers and water heater insulation commonly were installed as part of the energy audit.

Programs aimed at new construction, such as the utilities' Super Good Cents and Natural Choice programs and U.S. DOE and EPA's Energy Star Homes, educated the public about the benefits of energy efficiency, and certified new houses that met energy efficiency criteria. These programs advertised the benefits of energy efficiency to both buyers and builders of new site-built and factory-built homes. With growth in certification programs like Energy Star Homes, Super Good Cents, and Natural Choice programs in the last 10 years, appraisers now have less trouble assessing the value of energy efficient features.

The contractors for utility-run residential efficiency programs also provided information on special loans available to homeowners for energy efficiency upgrades. Generally, the commercial banks that provided these loans relied on the utilities' cost-effectiveness analyses. Anecdotal information indicates that utilization of special loan programs has been low, in part because of the relatively high interest rates for the loans, which raise the cost of the retrofits and diminish the cost-effectiveness of the measures.

Energy Efficient Mortgages: Energy Efficient Mortgages (EEMs) help homebuyers qualify for larger mortgages, so they can pay for energy efficiency retrofits on older homes, or for premium efficiency features in new homes. EEMs work by letting lenders stretch homebuyers debt-to-income ratios by up to 2 percent above usual ceilings, with the understanding that energy savings will offset the increases in mortgage payments. The additional funds must pay for energy efficiency features that exceed building code requirements. Energy features can be pre-built into the homes, or can be identified and financed in mortgages, then installed and inspected after the loans have closed. EEMs are available in Montana through many local and national mortgage lenders, including Norwest Mortgage, Countrywide, GMAC Mortgage and others.

Though the condition of Montana's older housing stock could justify many energy efficiency retrofits, anecdotal information indicates that few buyers are using EEMs. The economic rationale for EEMs is sound, but barriers have kept lenders, homebuyers, appraisers, and real estate agents from encouraging use of EEMs. A 1990 report identified some of those barriers.[247]

Lenders had misgivings about using EEMs because the instruments had the effect of qualifying marginal buyers for mortgages that might be too large. Further, since most financial institutions sell the mortgage loans they make, they were worried about the willingness of the secondary loan market to accept EEMs. Finally, lenders were concerned about complicating mortgage processing, and delaying closings. Energy audits, planning and other evaluations can be difficult to coordinate and schedule, and no one gets money until the loans close.

Homebuyers share with lenders many of the same concerns about EEMs, in particular, the increased debt. Apparently, many borrowers are uncomfortable increasing their debt loads, even if the increases would be offset by energy cost savings.

Appraisers cited difficulty finding properties with similar energy efficiency features for establishing comparable values, and a reluctance to incur liability by proclaiming that particular houses were "energy efficient." Real estate agents indicated that home shoppers were less interested in the energy consumption of houses than the presence of other amenities, and that fuel type rather than fuel bills were most important in decisions to buy.

DEQ's information about EEMs is nearly 10 years old, and should be updated through a survey of Montana lenders, real estate agents, appraisers and homebuyers. DEQ could then determine the extent to which people are using the EEM mechanism and whether it is appropriate to focus time and resources to this avenue of promoting energy conservation.

Future alternative capital programs: Low interest special loan programs or larger tax credits could encourage more cost-effective efficiency retrofits and equipment replacements in the residential sector. These might be more attractive than EEMs to homeowners and homebuyers. Funding such arrangements always is a problem; however, revenues from a carbon tax could be channeled through such programs toward investments that reduce greenhouse gas emissions.

Conclusion: Increasing the availability of low-cost capital for financing energy efficiency improvements in new and existing homes could lower energy use in the residential sector. A survey of the efficiency, condition and other attributes of building shells and heating plants in Montana's residential (and commercial) buildings would provide a basis for public and private efforts to market energy efficiency. DEQ should survey Montana lenders, real estate agents, appraisers and homebuyers to determine how well existing programs are working to encourage energy-efficiency investments.

5.5.2.5 Large commercial buildings and institutions

Like residential and small commercial buildings, large commercial buildings use natural gas primarily for heating. Large building owners could benefit directly from the same types of measures that reduce demand for natural gas in smaller buildings. About half of the utility cost savings from retrofits performed through DEQ's State Building Energy Conservation Program have been from reduced natural gas consumption (see p.1). The size of large commercial heating

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[247] Kelley, Pat. "Suggested Directions for DNRC Lender/Appraiser Program." Montana Department of Natural Resources and Conservation. March 1990

loads make it economically attractive to install capital intensive energy management and control systems, to hire energy management staff or contractors, and to contract for regular energy performance audits.

Large commercial buildings and large institutional facilities, such as hospitals and universities, could benefit economically from greater use of technologies that extract more energy from fuel. Natural gas-fired electric generating plants can produce electricity and supply heat that can be used for commercial processes, steam, or space and water heating. This approach, known as "cogeneration," uses the initial combustion of natural gas to turn turbines that generate electricity, then passes the hot exhaust gases through heat exchangers to recover heat for other uses. The net greenhouse gases that cogeneration plants produce can be less than or equivalent to emissions from many existing heating units, and they offset greenhouse gas emissions from coal-fired electric plants. Current-technology gas turbines are most attractive for facilities with large, relatively constant heating loads, and less so for those with variable natural gas demands, such as caused by large seasonal heating loads. As the size and cost of cogeneration equipment decline, cogeneration should become attractive for many more applications. (These technologies are discussed in the previous chapter, p.1 and p.1).

Conclusion: DEQ should spur greater penetration of high efficiency heating equipment and energy management systems through educational outreach programs targeted at commercial management staff. DEQ should follow the progress of BPA's fuel cell demonstration program and encourage Montana utilities to participate in the program. DEQ should routinely include an assessment of distributed generation in its programs with commercial and institutional buildings.

5.5.2.6 Industrial facilities

Industrial facilities are large consumers of natural gas. However, unlike the commercial and institutional sector, large industrial customers switch fuels as relative prices change, and maintain systems that allow greater flexibility. Moreover, energy costs are relatively minor for industrial customers, compared to the costs of labor and other inputs. Typical corporate rate-of-return policies and competitive demands require that industries look at quick paybacks and benefits.

In recent years, the convenience and relatively low price of the fuel have driven industrial demand for natural gas, as have efforts to comply with air quality standards and local air quality requirements. In particular, cement producers and petroleum refiners have offset their use of coal and petroleum products with more natural gas. This has brought about increases in greenhouse gas emissions attributable to the combustion of natural gas, but net decreases in greenhouse gas emissions overall.

Industrial energy efficiency opportunities are most effectively identified and implemented internally, rather than through state programs like those developed for other sectors. The U.S. DOE has targeted mining, refineries, and paper/pulp industries in its "Industries of the Future" program. These programs typically deliver innovative developments directly from the national labs to the industries. However, some DOE programs such as NICE3 require or encourage state participation.[248]

Conclusion: DEQ should continue to monitor the progress of industrial energy programs and make them available to industries in Montana when appropriate.

5.6 Fugitive methane emissions

Methane escapes into the atmosphere during all phases of the oil and natural gas fuel cycle. Methane also is released in petroleum production, transmission, storage, and refining processes. These emissions, termed "fugitive" methane emissions, occur at oil and natural gas production wells, gathering pipeline systems, treatment plants, valves, transmission pipelines, storage facilities, distribution pipes, and within buildings and gas-burning equipment. In 1997, methane emissions nationally from the oil and gas industries combined, at an estimated 6.2 million metric tons, were substantially less than those from waste management operations (primarily landfills), at 10.4 million metric tons, and from agricultural operations, at 8.6 million metric tons.[249]

Roughly one half of fugitive methane emissions occur during production of oil and natural gas. Natural gas often is found in the geological formations that produce oil. This natural gas usually is gathered and passed through treatment plants that yield marketable natural gas. The output then is shipped to markets via transmission pipelines. However, when gathering systems are not in place to take it away, natural gas is either reinjected back into the ground,[250] flared or vented. When natural gas is flared, most of the methane is converted to CO_2, but when it is vented, most of the gas released is methane. Demand for natural gas currently is great enough and the price is high enough to encourage oil producers to minimize the amount of natural gas they vent or flare. Between 1990 and 1997, one to two percent of Montana's annual natural gas production from oil and gas wells was vented or flared, for an average of about 730 mmcf per year. In the past, however, significant quantities of natural gas were vented and flared in Montana oil fields. In particular, Powder River Basin oil producers vented and flared large quantities of methane during the late 1960s (see Figure 5.5). This was because natural gas gathering systems were not in place during the opening years of that oil field. In 1968 and 1969, a volume of gas equal to over 35 percent of all natural gas produced in Montana was flared or vented.

The restructuring of the natural gas industry, combined with the growing economic value of natural gas itself, probably have contributed to greater care in handling natural gas, and an overall decline in fugitive methane emissions. As the gas industry restructures, large vertically integrated systems have been broken-up to several owners and operators.[251] Natural gas is now constantly metered at many more points in the overall system, as owners of the respective system

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[248] NICE3 is a grant program that provides funding to state and industry partnerships (large and small business) for projects that develop and demonstrate advances in energy efficiency and clean production technologies.

[249] U.S. Energy Information Administration. *Emissions of Greenhouse Gases in the United States 1997*. Pp.27-41.

[250] Natural gas often is reinjected into the formation that produces oil to maintain reservoir pressure, so more oil can be extracted. The natural gas acts like the propellant in an aerosol can.

[251] In the natural gas industry, vertical integration means that one firm might own several components of the natural gas system, such as the gas wells, gathering systems, transmission pipeline and distributions system.

components seek compensation for the use of their facilities, or track the gas commodity. Consequently, owners of natural gas systems are better able to monitor their respective facilities, and can fix leaks as they occur.

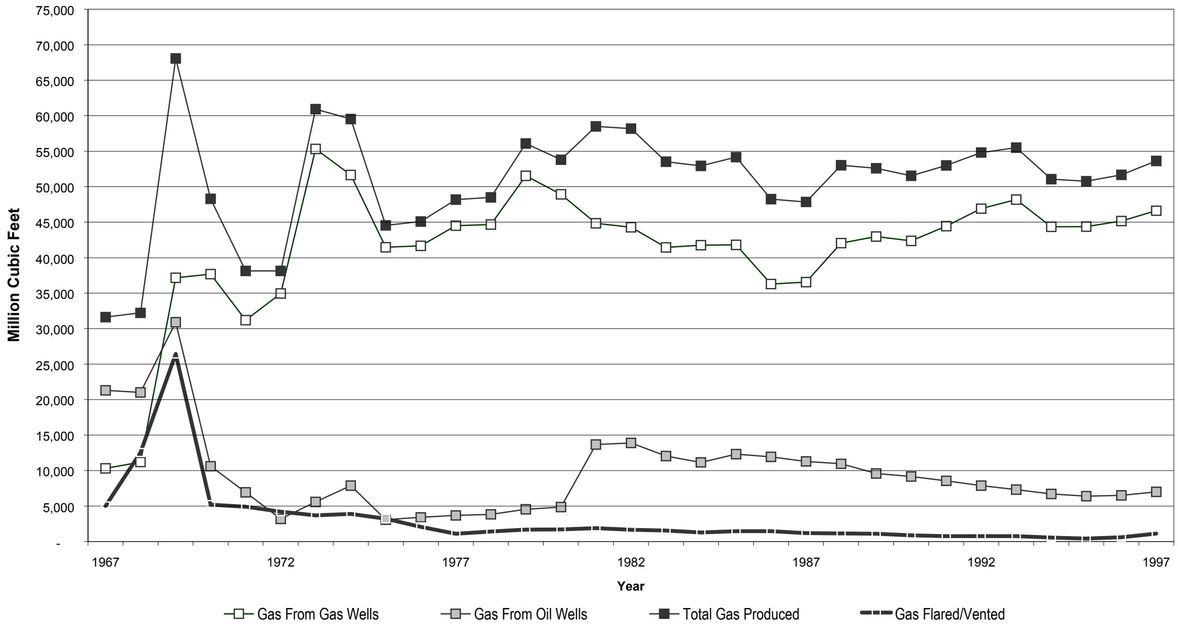

Figure 5.5: Natural Gas Volumes by Source (Oil or Gas Well), Volumes Flared or Vented.[252]

The EPA has initiated the Natural Gas STAR voluntary program, which encourages companies to become "Partners" by adopting cost-effective best management practices (BMPs) that reduce leaks and losses of natural gas. Although these BMPs were jointly identified by EPA and industry as cost effective, companies are asked only to implement those BMPs that make economic sense for their operations. Partners are also encouraged to consider implementing other Partner Reported Opportunities (PROs) that may be profitable for their companies. Natural Gas STAR acts as a technology transfer program for promoting innovative processes and technologies.

Conclusion: Encouraging more natural gas production, treatment, transmission and distribution companies to join EPA's Natural Gas STAR volunteer program would reduce methane emissions.

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[252] Historical Natural Gas Annual 1930 through 1997, DOE-EIA, 1998.

CHAPTER 6: CARBON TAXES AND TRADABLE EMISSIONS PERMITS

6.1 Introduction

Government has a variety of tools to regulate greenhouse gas emissions or any other pollutant. Economists and policy makers sort these into a continuum of options, with "command and control" methods at one end and "flexible" or "market-based" methods on the other. Command and control methods focus on precise emission reduction requirements for each emitter, and often call for specific ("prescriptive") reduction technologies. Market-based methods give emitters flexibility in the degree and method of emission reductions. Instead of direct mandates, market-based methods create incentives for emitters to seek lower cost and more efficient ways to achieve desired levels of environmental quality.

Montana's Greenhouse Gas Project investigated a number of proposals for market-based methods. Two market-based options, carbon taxes and tradable emissions permits, could cut across all sectors and may hold the potential to generate the greatest reductions in greenhouse gas emissions at the lowest overall cost.

Although it is flexible, market-based regulation is still regulation. Environmental regulation is often necessary to avoid or correct abuses of public goods (e.g., a healthy environment) that are not owned and are not bought and sold. Because such goods have no defined market value, they typically are undervalued. When resources are not properly valued by society, they are often used inefficiently. When the costs to society of a particular activity exceed the benefits to society, the activity is actually draining society's wealth. Regulating such an activity produces net gains for society.[253]

The air is a public good that is often abused because individuals can release waste gases into the atmosphere at very little cost (except where emissions are regulated). Clean air is valuable to people in general for promoting good health, productive agriculture, good water quality, and

[253] For instance, a 1997 EPA study, "The Benefits and Costs of the Clean Air Act, 1970 to 1990," found that between 1970 and 1990 the Clean Air Act cost $523 billion to implement, but produced savings of $22 trillion, primarily in reduced illness and loss of life.

other environmental necessities. When individuals release waste gases into the air, they can create costs for others for which they are not compensated. Unless the emitters are required to compensate for the costs they create, society—either some of us or all of us—pays those costs. Market-based regulations impose costs for emitting waste gases, placing value on a good that does not have a market value, and thereby promoting more efficient use of the resource.

Experience has shown that firms and individuals will not always clean up their operations, even when doing so could reduce their costs. In theory, firms in competitive markets, through profit maximizing and cost minimizing activities, should look for and make cost-effective innovations. In practice, however, there's no reason to believe that all profitable opportunities for innovation already have been discovered, that all managers have perfect information about those opportunities or that organizational incentives encourage innovation. In the real world, managers often have highly incomplete information and limited time and attention. Frequently, pollution means that resources have been used incompletely, inefficiently, or ineffectively. Regulations, when properly done, can become a part of the free market process, to the extent they become part of the way in which managers with highly incomplete information get more information.[254] By imposing costs on waste emissions, government can spur innovation by exploiting businesses' tendency to reduce costs.

6.2 Carbon taxes

6.2.1 Merits of a carbon tax

Most of the greenhouse gas released by human activities is carbon dioxide (CO_2) produced during fossil fuel combustion. Almost three-quarters of Montana's inventoried emissions are CO_2.[255] For many uses, fuel cost economics encourage greater use of high-carbon fuels. For instance, in many locations the cost of using coal to generate electricity is significantly lower than using petroleum or natural gas, even with the cost of applicable controls on regulated pollutants.

Placing a tax on carbon emissions would raise the cost of using high-carbon fuels such as coal, improving the cost-effectiveness of other, less carbon-rich fuels.[256] Such a tax would change behavior by raising the cost of emitting carbon-rich waste gases. To minimize costs, firms would adjust their processes to minimize carbon emissions. They would be free to choose how to do so. They could switch to less carbon-rich fuels, or reduce the amount of fuel needed in their processes. A tax would also raise the price of energy, inducing energy end-users to reduce

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[254] When forced to clean up, companies often find savings and innovations they didn't realize were available. A study of activities to meet regulatory requirements by preventing waste generation at 29 chemical plants found that of 181 waste prevention activities, only one resulted in a net cost increase. Most required little or no capital outlay, and of the 70 activities with documented changes in product yield, 68 reported increases. (Michael Porter and Claas van der Linde. "Green and Competitive: Ending the Stalemate." *Harvard Business Review*. September-October 1995, pp.120-134.)

[255] On a national level, in 1997, carbon dioxide accounted for 82 percent of U.S. greenhouse gas emissions. U.S. Energy Information Administration. Emissions of Greenhouse Gases in the United States 1997. October 1998, p.x.

[256] Theoretically, taxes could be placed on the other, less significant greenhouse gas emissions as well; however, procedures for measuring such emissions are not at all as mature and pervasive in the economy as those for measuring fuel use.

CO_2 emissions by using energy more efficiently. Perhaps most importantly, a carbon tax would reduce emissions without creating market distortions associated with prescriptive abatement requirements. Firms could devise their own approaches to avoid paying the tax.

A carbon tax would create additional benefits to society. Fossil fuel combustion produces not only CO_2, but also other emissions that are harmful to human health and the environment. The tax could provide additional incentives to reduce emissions of these other pollutants, many of which already are regulated under the federal and state clean air acts. It also would reduce emissions of substances, such as mercury, that are being considered for regulation.

A carbon tax could probably be collected with limited extra cost and paperwork. Taxes already are collected at a number of points in the distribution and production of petroleum, coal and natural gas. A carbon tax could be collected at generating plants, through natural gas utilities or at petroleum fuel racks.[257]

A carbon tax signals the government's interest in reducing greenhouse gas emissions and in improving the efficiency of the economy. To minimize the impact on the economy, a carbon tax should be phased in over time, which would avoid inefficient equipment being replaced long before it is worn out. Ideally, a carbon tax should be set at a level that reflects the environmental cost of climate change; however, the current estimates of the impact of climate change vary widely and are subject to much uncertainty. The initial carbon tax would be more acceptable if set toward the lower end, or even below, the uncertain estimates of future impacts.

6.2.2 Illustrative case

For illustration, DEQ calculated the cost to consumers of a carbon tax set at $10/metric tonne.[258] The rate of the carbon tax per unit of energy would be different for each fuel, because of differences in their carbon content. A $10/tonne tax is modest in the context of current national and international proposals. At this level, the immediate impact of a carbon tax on greenhouse gas emissions will be mostly symbolic, demonstrating the government's commitment to acting on the problem. Nevertheless, demonstration of that commitment is essential to convince investors to move to more energy efficient and less carbon-intensive technologies.

Based on 1990 consumption figures, this tax would have raised over $78 million dollars in Montana.[259] About 55 percent of the tax would be levied on the fossil fuels, almost entirely coal,

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[257] Carbon in fossil fuels—coal, petroleum and natural gas—mined or produced in Montana but exported out-of-state would not be taxed in Montana, since those fuels would not be consumed in Montana. Coal burned for electric generation in Montana would be taxed in Montana, though the electricity might be exported to out-of-state end-users. Biobased fuels, such as wood or the ethanol portion of gasohol, would not be taxed, because they are part of the natural carbon cycle that ultimately adds no net carbon to the atmosphere. (Of course, fossil fuel used in making the biobased fuels would be taxed.)

[258] The cost of reducing greenhouse gas emissions is conventionally given in terms of dollars per metric tonne of carbon emissions. A metric tonne (1,000 kilograms) equals approximately 2,200 pounds. A tax of $10/tonne of carbon is equivalent to $2.50 per ton of carbon dioxide.

[259] The revenue raised by a carbon tax can be compared to the revenues of industries vulnerable to climate change. While DEQ has not estimated the economic costs attributable to climate change, agriculture can be used as a proxy for illustration, as it is highly influenced by climate. The gross receipts from a $10 per tonne carbon tax would be less than 5 percent of the revenue received in Montana for agricultural products, or less than the annual impact attributable to normal climate variability. Climate variability, particularly the amount and timing of precipitation,

consumed at electric generating plants. Thirty-five percent would be levied on petroleum products and less than 10 percent on natural gas. The direct cost of carbon taxes to Montana households would range between $40 and $80, typically near the low end of that range.

Rates for $10/tonne carbon tax applied to selected fuels

Electricity	-	3.3 mills/kWh from a plant burning Montana coal[260]
Natural gas	-	$0.15/mcf
Gasoline	-	$0.024/gallon*
Diesel	-	$0.028/gallon*

*Direct cost. Fuel costs would rise by an additional $0.003 per gallon to reflect costs refineries would incur from a carbon tax on fossil fuels consumed to manufacture petroleum products.

Not all the tax would be paid by Montana consumers. A certain amount would be paid by non-Montanans who purchase motor fuel while driving through Montana. A far larger amount would be paid by non-Montanan electricity consumers if the following occurs: 1) all the tax on coal-fired electricity was passed on to consumers and 2) future electricity sales, in-state and out-of-state, follow the pattern of long-term contracts and electric generating plant ownership existing prior to MPC's sale of its generating plants. Given those two assumptions, Montana consumers would pay slightly more than half the money collected under a $10/tonne carbon tax.

The two assumptions about the electricity market might not hold, in which case Montana consumers would pay even less than half the money collected under a carbon tax. Montana generating plants, because they now are selling into a deregulated market, might not be able to raise their prices to reflect the carbon tax. If they can't raise their prices, more of the tax would be shipped out of state. Under this scenario, about two-thirds of the amount collected through the carbon tax would be paid by the owners of the electric generating plants and by non-Montanan drivers.[261] Montana consumers would pay the remaining one-third of the carbon tax.

6.2.3 Acceptability of a carbon tax

The political acceptability of a carbon tax would depend in part on what was done with taxes collected. A carbon tax could be used to encourage future reductions in the industries subject to the tax. Sweden took this approach as part of its efforts to control NO_x emissions from large power and heating plants. Starting in 1992, the tax was assessed based on total NO_x emissions, but then refunded based on the amount of NO_x emitted per unit of energy produced. Cleaner plants got a net refund; dirtier plants paid a net tax. The plants as a group reported a 35 percent reduction in emissions in two years.[262]

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greatly impacts agricultural revenue in Montana, by increasing irrigation costs and reducing yields. Even without considering the cost of other environmental or health damages, this suggests, though it does not prove, that a modest carbon tax actually understates the true cost of climate change.

[260] The carbon content of coal varies by type of coal and where the coal was mined. Cost is for electricity is at the customer's meter.

[261] Another possibility is that the generating companies could force some of the tax back on the fuel producers. A carbon tax of $10/tonne of carbon is equivalent to an average of $4.50/ ton of Montana coal. This equals about one-third the cost of coal delivered to Montana utilities. Price of coal from: U.S. Energy Information Administration. Table 34. Receipts and Average Cost of Coal Delivered to Electric Utilities by Census Division and State

[262] OECD. *"Environmental Taxes and Green Tax Reform."* Paris 1997.

A carbon tax, like any pollution tax, could be used to clean up or reduce the impacts of the polluting activity. For instance, the state of Washington levies a surcharge on the sale of products that contribute to litter.[263] This litter tax revenue is then used for cleanup projects. The income from a carbon tax could be used to fund energy efficiency projects around Montana.

The most politically acceptable use of carbon taxes might be to offset existing taxes, causing no net increase in taxes. For instance, property taxes, currently a prominent public issue, could be reduced by an amount equal to the carbon tax revenues. The $10 per tonne carbon tax would have raised $78 million in 1990, and could have offset almost 15 percent of the total state property taxes levied that year.[264] Since, as noted above, some of the carbon tax would be paid by non-Montanans, a carbon tax would actually reduce net taxes paid by Montanans if carbon tax revenues were used to offset other state taxes.

A carbon tax, even if used to offset property taxes and reduce most Montanans' tax burdens, could present two possible equity problems. First, only owners of taxable property would benefit from the offset. For instance, renters would only benefit from property tax reductions if landlords passed through the tax savings in the form of lower rents. Competitive pressures would tend to push rents down in areas where landlords compete for renters; however, landlords could reap the benefit of property tax offsets in areas with housing shortages.

Second, 55 percent of the carbon tax would fall on generating companies, primarily the Pennsylvania Power and Light (PP&L) subsidiaries that are the new owners of the Colstrip plants. While this is exactly where reductions in carbon dioxide emissions are needed, this concentration of the tax could be problematic if PP&L is unable to pass the tax through the wholesale market. A carbon tax of this magnitude is unlikely to make the Colstrip plants uneconomical to run, but it could affect the long-term profitability of owning the plants. The Colstrip plants are relatively cheap to operate, so the addition of 3.3 mills/kWh in operating costs is unlikely to price them out of the market. PP&L's plants would probably run no matter who (customers and/or generators) ultimately pays the tax.[265] However, if PP&L is unable to pass the tax along, it might not be able to make the profits it was anticipating. It is not publicly known if the price paid for Colstrip contained an adjustment to account for the risk of future carbon regulation, though the issue of a carbon tax was explored by at least some of the parties as part of their "due diligence" evaluation of the value of MPC's properties. Because the amount of property taxes paid by generating facilities is so large, recycling the carbon tax as property tax

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[263] See Washington Department of Revenue under Rules and Laws, Rules Administration, Washington Administrative Code, 458-20 Excise Tax Rules, 243-litter tax.

[264] Total Montana property taxes levied in 1990 was $542,138,877. Montana Department of Revenue *Biennial Report, 1988-1990*, p.157.

[265] This assessment is based on anecdotal reports from within the utility industry, and inferences drawn from a Northwest Power Planning Council (NWPPC) report, *Analysis of Bonneville Power Administration's Future Costs and Revenues* (1998). That report included modeling of the dispatch of western power projects under different scenarios of demand for electricity. The model continued to dispatch the Colstrip plants, even with annual demand growth reduced from the base case of 1.5 % to the low case of 0.5%. This indicates that the plants' operating costs are below those of other thermal plants in the western interconnected system, given existing transmission constraints. It suggests that a modest carbon tax would have little affect on the amount that the Colstrip plants would be run.

relief would have substantial benefits for all utilities, though it would not come close to offsetting the cost of the carbon tax.

In general, it would be risky for an individual state to take the lead in imposing a new type of tax. While numerous states are imposing some pollution taxes,[266] and some states discuss carbon taxes in their own state greenhouse gas action plans, no states in the U.S. have imposed a carbon tax.[267] One of the significant risks of imposing a carbon tax is that it could cause businesses to relocate to other states. Montana may be better positioned than many states to escape such consequences, since the tax would be paid mostly by businesses that can't relocate (generating plants), or by consumers for whom fuel cost is a minor factor (tourists). Further, if coupled with a property tax cut, a carbon tax would reduce the cost of doing business in Montana for most businesses. This reduction, however, probably would not offset the cost of the carbon tax for energy intensive industries. Accordingly, a state carbon tax would face opposition from those who see it as a self-imposed competitive disadvantage on certain businesses. A national carbon tax might be more acceptable, as it would affect the economies of all states at once.

The effect of a carbon tax at the level examined by DEQ would be slight, at least initially. On the demand side, a $10/tonne tax is too low to cause most consumers to cut consumption significantly in the short term. If the electricity market refuses to pass along the tax, it would have zero immediate impact on electricity consumption. However, in either case, a tax would give the market additional reason to favor more efficient buildings, appliances and vehicles in the future, and thereby would affect consumption in the long run. Given the amount of potential efficiency improvements that are cost-effective at current energy prices, the impact on future consumption could be substantial. Imposition of a tax, even a minimal tax, would have much more effect on the supply side, signaling investors that, when financing new generating resources, facilities that use less carbon-intensive fuels are less risky.

Conclusion: The economic impact of different levels of carbon taxes on the Montana economy should be investigated before a state carbon tax is adopted. In particular, the impact of carbon taxes on the operation of generating plants in Montana should be modeled, both as a state tax and a national or regional tax covering the interconnected system of which Montana plants are a part. A national carbon tax that would be phased in appropriately and that would offset existing taxes might be the better option to explore.

6.3 Tradable emissions permits

Tradable emissions permits are promising regulatory tools for reducing emissions of greenhouse gases and other pollutants. While the total amount of pollution allowed under a tradable permit system is set by government, individual emitters can determine for themselves the most efficient amount of emission reduction and the cheapest way to attain them. Tradable permits have been used in the United States since 1995 as part of the successful effort to economically control sulfur dioxide (SO_2) emissions from electric generation plants and thereby reduce acid rain.

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[266] See the special supplement of *State Tax Notes: "Harnessing the Tax Code For Environmental Protection: A Survey of State Initiatives."* Tax Analysts, Arlington, VA. April 22, 1998.

[267] Several European countries (Norway, Sweden, Denmark, Finland and The Netherlands) have implemented some version of a carbon tax; however, the EU has decided to make such a tax optional for each member state.

Because the number of major emitters of carbon dioxide in Montana is limited, a regional or national tradable emissions permit system would be more appropriate than one limited to the state.

6.3.1 How tradable emissions permits work

A tradable emissions permit system (sometimes called a "cap and trade" system) sets a limit ("cap") on total emissions of a given pollutant in a given area, and establishes "rights" to emit that can be traded on the open market. First, authorities determine the total amount of allowable emissions for their jurisdictions (e.g., an industrial region, a geographic area such as the northwest U.S., or the entire country). Then, they create property rights for emissions by issuing a number of emissions permits or "pollution rights." The permits allow holders to emit a specific amount of a specific pollutant over a specific period. Initially, to establish a "market," authorities may sell or give away these permits to each emitter.[268] The sum of the permits made available to all emitters equals the total emissions limit set by the authority. The total emissions cap might stay the same, or might be reduced over time to eventually reduce total emissions of particular pollutants.

In a tradable emissions permit system, emitters can choose both how to abate emissions and how much to abate. Should they choose to abate emissions, emitters may select the method of abatement, be it through installing smokestack scrubbers or switching to cleaner fuels. Emitters can use, buy, sell, trade, or hold permits, depending upon their needs for a given time period. They can use their total emissions allotments, or sell unused portions to other emitters if they have more than they need. They can buy additional permits from other emitters at the market price, should that be cheaper than fuel switching, investing in additional emission control technology, or otherwise altering their processes to work with their existing number of permits. They may also save permits for later use in certain circumstances.

Through market interactions, emitters can make expenditures to reduce total emissions at the lowest cost to the entire industry, over one or several periods. For example, the owner of an older facility, one that would be expensive to retrofit with abatement equipment, could instead buy permits from a firm with a newer facility that does not need its entire permit allotment. The emitters make their own calculations about the costs and benefits of the trade, and negotiate the value of the permits. No net increase in emissions would result from the trade. Trading could induce owners to reduce emissions to less than their permits, so they can sell excess permits. Indeed, an industry might collectively reduce emissions ahead of schedule and bank permits, perhaps for trades at later times when more expensive abatement technology might be necessary, as appears will be the case in the national SO_2 program.

The market prices of permits are determined through transactions between emitters, rather than by central authorities. These prices are determined by the amount of pollution reduction targeted under emissions caps, and the incremental costs of abating additional units of emissions. Generally, the prices of permits are higher in jurisdictions with more restrictive emissions

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[268] The point is to establish a property right for emissions. For instance, the federal SO_2 program initially gave each emitter one permit per 1 ton of emissions.

caps,[269] because the values of permits reflect the local cost of reducing emissions. Until the regulatory limits start to constrain the polluting activity, the permits will have little value.

Tradable emissions permits have advantages over more prescriptive regulatory approaches, such as point source or best available control technology (BACT) regulation, because they allow economics to determine the deployment of control technologies, and create incentives to close inefficient facilities. For instance, dirtier operations have two incentives to close under an emissions permit system, incentives that do not exist under prescriptive systems. First, emissions permits place a cost on emitting regulated pollutants. Even if permits initially are given rather than sold to firms, cleaner operators have a competitive advantage over others, because they can earn additional revenue from trading unused permits (unless the initial distribution of permits is biased against cleaner firms). Second, dirtier firms have the opportunity to gain income even when shutting down, by selling their permits to operators of newer, cleaner, more efficient, more valuable facilities. In contrast, under point source regulation older plants would likely continue running since that might be the only way to salvage value from their assets.

Tradable permits allow market forces to balance the costs and benefits of operating different facilities, and reward operators for reducing emissions below their respective permits. In this way, emissions are cut in the cheapest way possible, as determined by each emitter. Eventually, market forces bring the cost of abatement into equilibrium with permits, whereas abatement technology costs will be spread unevenly under command and control regulation.

6.3.2 Tradable carbon emissions permits

Tradable carbon emissions permits would have advantages over carbon taxes. With permits, regulators would not have to guess at a tax level that would achieve target carbon emissions reductions. A carbon emissions cap would set the target emissions level up front. An emissions cap would not allow carbon emissions to increase as the economy grows, while carbon taxes would permit increased carbon emissions, as long as the tax was paid. As the economy or energy use increases, the value of emissions permits would increase (assuming that the cap stays the same), increasing the cost of emitting greenhouse gases, and inducing additional innovations that reduce emissions. Additionally, emitters have an incentive to police each other under a tradable permit system, to prevent competitors from gaining advantages by cheating (emitting more carbon than their permits would allow) or any other unfair behavior. Since emitters would own their emissions rights, they would defend the value of their permits as they would any other property right or asset. A loosely enforced permit system would adversely affect the asset value of carbon emissions permits.

Like other regulatory tools, permits are not perfect and don't fit every situation. A tradable carbon emission permit system might not be feasible at the state level. The number of emitters covered by a system must be large enough to guarantee sufficient participants in the market, and to produce an adequate impact. Thus, to effectively reduce greenhouse gases, the most realistic scale for tradable carbon emissions program may be at the national or international level.

On the other hand, if the number of transactions becomes too large, it might be impractical to implement a tradable carbon emissions system. There are countless major sources of greenhouse

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[269] That is, in areas with emissions caps much lower than historical, unregulated levels of emissions.

gas emissions in the world, located in over 100 independent countries. Assigning and policing permits to all of these sources could become a bureaucratic nightmare.

Tradable permits would not do well with dispersed emissions. The most obvious example is motor vehicles. A system that would allow individual drivers to make trades is difficult to imagine. A carbon tax would be a far simpler method for sending a market signal in the case of motor vehicle emissions.

The question of how to distribute emissions permits initially is another issue that must be addressed. While it might be less critical to the developed market economies, future economic development in nations that do not currently have energy intensive economies might be hampered by limits based on their historical carbon emission levels. Additionally, transaction costs could make the system unusable. As energy distribution systems of all nations are restructured and deregulated, the number of participants in energy transactions is increasing significantly. These and other issues are being debated in on-going international negotiations.[270]

6.3.3 Experience with tradable permits[271]

A national tradable emissions permit program has existed in the United States since the SO_2 program was enacted through Title IV of the 1990 Clean Air Act Amendments. The program was implemented to reduce acid rain-causing emissions from electricity generators at minimum cost. Under previous prescriptive regulation, firms were told exactly what they had to do to lower emissions, regardless of whether these were the most cost-effective means of achieving reductions. Reductions that were achieved were very costly on average. This prompted the federal government to look at market-based regulatory tools as a way to reduce pollution at a lower cost.

The initial phase of permits in the federal SO_2 program has been successful, with a few surprises. Phase I, which lasts from 1995 to 2000, originally covered 263 generating units at the 110 dirtiest generating facilities in the nation. An additional 182 units joined Phase I as substitution, or compensating units, bringing the total to 445 units under Phase I. Data indicate that SO_2 emissions at these units were reduced by almost 40 percent below their required level in 1995.[272] Participating facilities are reducing emissions ahead of schedule as set within the program and at a cost far lower than was originally predicted. By the end of 1996, two years into the program,

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[270] The status as of March 1999 of domestic emissions trading systems in seven countries may be found at the OECD climate change site.

[271] Much of the discussion in this section on the performance of the SO_2 program was based on two articles:

Kerr, Richard A., "Acid Rain Control: Success on the Cheap," *Science*. 1998, vol. 282, November 6. pp. 1024-1027.

Bohi, Douglas R. and Dallas Burtraw, "SO2 Permit Trading: How Experience and Expectations Measure Up", Resources for the Future. Discussion Paper 97-24, February, 1997.

Other articles, papers and reports on the success of the sulfur trading program can be accessed at EPA's website.

[272] Source: EPA Acid Rain Program Overview website. Before permits, the 110 original participating facilities emitted about 4 lbs. of SO_2 per mmBtu on average. Under the Phase I of the sulfur program, the level is slated to decrease to 2.5 lbs/mmBtu and in Phase II, starting in 2000 as more emitters enter the program, the level will be brought down to 1.2 lbs./mmBtu.

SO_2 emissions were down to 5.4 million tons, 35 percent below the set limit of 8.3 million tons.[273] Operators are saving the unused emission permits, in this case worth 2.9 million tons of SO_2, for tougher standards in Phase II, which begins in 2000.[274] The banked permits will allow emitters to more slowly phase-in expensive reduction strategies that will be necessary to meet the tougher standards.[275]

Emissions reduction under tradable permits cost about $0.8-1.0 billion per year as of 1997. This is far below initial forecasts of up to $10 billion per year made by industry and energy experts. It even beats the $4 billion estimated by EPA, an estimate considered very optimistic at the time.[276] Part of the lower cost is attributable to the flexibility of the permit program, which led to unexpected savings through fuel switching and the widespread use of scrubbers. Once utilities seriously committed to investing in these technologies, vendors of the technologies started competing with each other by lowering prices. Thus, scrubbers were among the least expensive abatement technologies used.[277]

There have been fewer trades than expected. Firms instead have reduced emissions by using the less expensive technologies. The longer-term, more expensive investments that were expected to accomplish emissions reductions have been delayed for future years, when standards tighten. Overall, the generators have responded to the program with technology research and development, and innovative cost cutting, rather than numerous trades. This is an acceptable result, since the goal of the program is to reduce emissions at the least cost, not to ensure that companies follow some specific regulatory procedure. More trades are likely in the future, however, as standards become more stringent.

The U.S. has yet to establish a national permit program for any criteria pollutant regulated under the CAA other than SO_2. The SO_2 program is still in the preliminary stages. Tradable emissions permit programs have been proposed for NOx and emissions that cause regional haze.

6.3.4 Feasibility of a tradable carbon emissions permit program in Montana

A program of tradable carbon emissions permits could work in Montana if the program were part of a national plan.[278] Because of their relative small number and relatively large emissions, electric generating plants, petroleum refineries and large industrial facilities are likely to be

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[273] Kerr, Richard A., "Acid Rain Control: Success on the Cheap" *Science*. 1998, Vol. 282, November 6. p.1026.

[274] White et al. estimate that the total number of permits banked will be 9.4 million tons in 2000. White, K.D., Energy Ventures Analysis Inc., and Van Horn Consulting. *The Emission Allowance Market and Electric Utility SO2 Compliance in a Competitive and Uncertain Future*. Prepared for the Electric Power Research Institute, EPRI TR-105490s. 1995.

[275] The most likely switch will be to natural gas, which will also reduce greenhouse gas emissions. This is a good example of how programs to control one pollutant can have multiple benefits.

[276] Kerr, Richard A., "Acid Rain Control: Success on the Cheap", *Science*. 1998, vol. 282, November 6. p1025.

[277] For additional information on how the SO2 program performed as of 1996, see the U.S. Energy Information Administration paper entitled "The Effects of Title IV of the Clean Air Acts Amendments of 1990 on Electric Utilities: An Update." March 1997.

[278] A national plan, or for that matter, any plan covering an area wider than just one state, would be more economical. In general, the larger the area covered, the more low-cost opportunities can be found. Thus, a plant with only moderate or high cost reduction opportunities nearby could go further afield to buy low-cost reductions.

covered in the first phase of any tradable emissions permit program. There are not enough such facilities in Montana to make an in-state permit market. Furthermore, the cost of creating and administering a permit program, and the lack of economies of scale, may prove too much for Montana or for any individual state. Also, pollution generated in Montana does not necessarily stay within state nor does the electricity produced. Some of the benefits and costs of a state program would go out of state and possibly distort market signals within an in-state permit system. Thus, a permit program should be considered as a future and long-term instrument for reductions contingent on national legislation.

The recent deregulation of utilities in Montana provides a good reason to believe permits would work here. With deregulation, utilities in Montana are now more competitive than previously and have incentives to minimize costs. Thus, they stand poised to take advantage of permits when they are available.

Conclusion: DEQ should monitor development of national and international tradable carbon emissions permits programs as part of market-based approaches to controlling greenhouse gas emissions.

CHAPTER 7: MAJOR INDUSTRIAL SOURCES

7.1 Overview

Montana does not have as many industrial facilities as Colorado, Washington or other populous states in the region, but the ones it has are large producers of greenhouse gas. Montana's 1990 greenhouse gas inventory found that about two-fifths of the state's total greenhouse gas emissions could be attributed to the industrial sector. Over half of that comes from three industries:

- An aluminum plant in Columbia Falls.
- Petroleum refining at the three refineries in the Billings-Laurel area, and the one in Great Falls.
- Cement plants at Montana City (near Helena) and Trident (near Bozeman).

These plants already are subject to federal air pollution control regulations under the Clean Air Act. In the course of meeting these regulations, these industries might be able to reduce their emissions of greenhouse gases through increased energy efficiency or waste reuse and recycling techniques.

DEQ has no suggestions for major new government efforts to reduce greenhouse gas emissions from these sources.

7.2 Aluminum reduction plant[279]

The Columbia Falls Aluminum Company (CFAC) is located at Columbia Falls, just outside Glacier National Park. About 10 percent of the inventoried greenhouse gas emissions in Montana are released during the reduction process.[280] Generation of the electricity used by CFAC is responsible for an additional 5 percent of statewide emissions.[281] The plant is not

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[279] At a reduction plant, an electric current is passed through alumina ore to produce aluminum. In contrast, at a smelter, iron, gold or other metals are extracted by heating the ore by burning fuel.

[280] Estimates of emission factors and GWPs of the PFCs released vary among experts and have changed over time. Emissions reported in the Montana inventory would be lower using different estimates. Actual emissions from CFAC aren't publicly available.

[281] The 5 percent figure assumes that the emissions from fossil-fueled electricity generation are apportioned among all users by the amount of electricity they used. The suppliers that CFAC actually used may not have relied on fossil-fuel generation to the same extent as the state average.

expected to expand its operating capacity in the near term. The release of greenhouse gases is expected to drop as new technologies are installed to improve production and to reduce the release of regulated air pollutants.

CFAC produces over 185,000 tons of aluminum a year, making it about average among plants in the Pacific Northwest. (The Pacific Northwest contains 9 of the 23 aluminum plants in the United States.) In 1999, the plant was bought by Glencore, a Swiss firm.

Aluminum production results in emissions of pollutants controlled under the federal Clean Air Act. The major concerns are fluorides and polyorganic molecules (POMs), which are toxic air pollutants regulated under the Hazardous Air Pollutants program.[282] These are controlled through baghouses, electrostatic precipitators, high pressure-drop scrubbers and operating practices. CFAC also is monitored for emission of carbon monoxide, sulfur dioxide, volatile organic compounds, and particulates, but the area surrounding CFAC is not in violation of National Ambient Air Quality Standards (NAAQS) for these pollutants. CFAC, like all aluminum plants, must comply with Maximum Achievable Control Technology (MACT) regulations, administered by the state under authority from the federal government.

The major greenhouse gases from aluminum reduction are the perfluorocarbons (PFCs): perfluoromethane (CF_4) and perfluoroethane (C_2F_6). These are generated during "anode effects," transient disruptions of the production process, which are characterized by a sharp rise in voltage across the pot. Anode effects occur both periodically and randomly in aluminum reduction cells. (PFCs are not produced when aluminum is recycled.)

The frequency, duration, and voltage profile of anode effects depend primarily on the cell technology and operational procedures, in particular how the alumina is fed into the cell. The frequency of anode effects can be reduced by improvements in (1) managing alumina additions and other process parameters, (2) algorithms controlling automated processes, and (3) training of personnel. The average duration of anode effects can be reduced by improving the suppression response of potroom personnel. Aluminum companies have an interest in reducing anode effects, since they degrade smelting efficiencies. The increased monitoring of operations at the facility to control fugitive POMs and fluoride, as required under MACT, should decrease anode effects.

Carbon dioxide is created as the anodes, made of petroleum coke, burn off in the course of producing the aluminum. While these emission are substantial (almost 1 percent of the inventoried emissions in Montana), they are dwarfed by the impact of the PFCs.

Aluminum reduction uses prodigious amounts of electricity, about one-quarter of all the electricity consumed in Montana. The carbon dioxide emissions associated with the production of this electricity were inventoried in the industrial sector emissions. CFAC also uses large amounts of natural gas; however, this only equals around 1 percent of natural gas consumed by industry in Montana. Emissions from combustion of natural gas also were inventoried in the total industrial sector emissions.

CFAC participates in the Voluntary Aluminum Industrial Partnership, an industry partnership with EPA. CFAC has installed a computerized anode effect suppression system to reduce PFC

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[282] See EPA's website for more information on air toxics.

emissions. This system, which is activated at a preset voltage, significantly reduces anode effect duration. CFAC is also investigating the optimum alumina feed rate to reduce anode effects. A feed rate must be selected that prevents over-feeding, which results in a layer of undissolved alumina beneath the molten aluminum pad. Besides reducing PFC emissions, CFAC expects these activities to reduce hydrogen fluoride generation and resultant fugitive emissions. Controlling these emissions is particularly important since CFAC employs vertical stud Soderberg cells to produce the aluminum, and these cannot be hooded for pot gas collection.

Conclusion: DEQ should support CFAC's participation in the Voluntary Aluminum Industrial Partnership.

7.3 Petroleum refineries

Refining petroleum is an energy-intensive operation. Carbon dioxide emissions from fossil fuel combustion at refineries account for about 8 percent of Montana's inventoried greenhouse gas emissions. The carbon dioxide released during the refining process is equivalent to 10-15 percent of the carbon dioxide released when the product fuels are combusted in engines. Put another way, using a gallon of gasoline results in release of over 22 pounds of carbon dioxide, about 2.5 pounds when the gasoline is made and about 20 pounds when the gasoline is burned.[283]

Montana's refineries had a combined output of around 150,000 barrels a day in 1997, mostly from the three refineries in Billings and Laurel. While these refineries are relatively small on a national scale, they are the main source of petroleum products for this region. Most of the petroleum products used in Montana come from Montana refineries. In 1996, almost half the fuel products from Montana refineries were shipped out of state.[284] Of the amount shipped out of state, almost half went to Wyoming and beyond; eastern Washington, northern Idaho and North Dakota also received Montana product.[285] Production at Montana refineries has increased over 15 percent since 1990. Further increases are unlikely without expansion of the refineries. Montana refineries processed about 55 million barrels of crude oil in 1997. Most of that crude came from Canada and Wyoming.

Petroleum refineries emit a variety of gases that already are subject to regulation, including sulfur dioxide (SO_2), hydrogen sulfide (H_2S), ammonia, aromatics, carbon monoxide (CO), nitrogen oxides, aldehydes, and hydrocarbons. Refineries are the major reason both Laurel and Billings have been out of compliance with the federal Clean Air Act requirements for sulfur dioxide.[286] Refineries accounted directly for 55 percent of the SO_2 released in the Billings area

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[283] The estimate of carbon dioxide released when petroleum is refined is based on the performance of Montana refineries. Because Montana refineries are relatively small, this estimate could be different from the national average. Some fuel additives, which constitute an extremely small portion of the product shipped from Montana refineries, actually are produced outside Montana.

[284] Asphalt and much of the lubricants produced in Montana are used in Montana.

[285] Pace Consultants. *YPL Reroute EIS—Supply and Demand Analysis*. 1998. p.C-29.

[286] Laurel was designated a non-attainment area in 1978. Billings was put under an SO_2 "SIP call" in 1993, meaning computer models showed the area was at risk of violating the national air quality standards and that a plan to reduce emissions had to be prepared and put into operation. While EPA has yet to approve the plan as meeting federal requirements, the plan is being enforced on the state level.

in 1997. If one includes co-generation and sulfur recovery plants associated with one of the refineries, refining operations accounted for 88 percent of SO_2 emissions. Both Billings and Laurel have seen significant reductions in SO_2 emissions in recent years. Because of air quality issues, and the possibility of sanctions under the Clean Air Act, improving energy efficiency (and thereby reducing carbon dioxide emissions) cannot always be the priority goal for the refineries.

Because of refinery operations are complex and unique to the industry, DEQ did not develop any recommendations for the refinery industry. Some companies, such as BP Amoco, are making concerted efforts to improve their energy efficiency and reduce emissions of all kinds. Efforts like these might demonstrate the feasibility of new methods or technology that would be feasible in Montana.

Greenhouse gas programs in the transportation sector could change the amount of emissions from refineries. Increasing transportation fuel efficiency, could reduce—or more likely slow the increase—in the demand for petroleum products, which would affect refinery emissions.

Conclusion: DEQ should monitor national and international efforts by the petroleum industry to improve energy efficiency and reduce emissions in refining operations.

7.4 Cement plants

Cement plants accounted for over 1 percent of the inventoried greenhouse gas emissions in Montana. The primary release of CO_2 during cement production occurs in the manufacture of clinker, the material that is collected from the kiln and mixed with gypsum to form the final product. One component of clinker is lime (calcium oxide, CaO). When limestone is heated to form lime, CO_2 is released. Carbon dioxide also is released from the fuels used to fire the kilns. In 1998, Montana's two cement plants produced over 600,000 pounds of cement clinker, only slightly more than in 1990.[287]

Cement plants are subject to regulation under the federal Clean Air Act. They typically emit NO_x, SO_2, and CO. These are reduced through both process and mechanical controls. Process controls include balancing the alkali content in raw materials and fuels, reducing kiln volume load, and burner adjustment. Mechanical controls include electrostatic precipitators and baghouses.

DEQ is not aware of any methods for reducing the amount of CO_2 released as the limestone is converted to lime. Moreover, the prospects for reducing the amount of carbon released by fuel burning are not good. If the price of natural gas rises, cement kilns may switch to other sources of fuel. One Montana plant recently switched to petroleum coke and synthetic coal, which will increase CO_2 emissions. DEQ is working with this plant to evaluate the possibility of substituting wood waste for a portion of its kiln fuel.

Conclusion: DEQ should continue its efforts to find ways to use waste products in cement production.

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[287] Nicole Richins, Holnam, Inc. and Joe Scheeler, Ash Grove Cement Company. Phone conversations with Mark Lambrecht, DEQ, 1999.

CHAPTER 8: WASTE MANAGEMENT

8.1 Introduction

Waste product invariably means wasted energy. If waste can be avoided, the energy used to create it can be saved, and the greenhouse gas emissions and other pollution associated with that energy use can be avoided. Once wastes are disposed of, they can release additional greenhouse gas emissions. Almost all waste in Montana goes to landfills. Methane is the best known emission from landfills, because of the problems it causes at ground level. Landfills also release carbon dioxide and gases such as chlorofluorocarbons (CFCs). An EPA report, Greenhouse Gas Emissions From Management of Selected Materials in Municipal Solid Waste (1998), presents information on the links between various municipal solid waste management options and greenhouse gas emissions, along with emission factors for the different wastes.

Waste management strategies for reducing greenhouse gas emissions are, in order of preference, pollution prevention, recycling, and landfill management. A discussion of the link between waste and climate change, as well as a description of programs to reduce waste may be found at EPA's website.

8.2 Pollution prevention

Pollution prevention, or source reduction, protects the environment by avoiding pollution rather than controlling it once it is created. The goal is to get the same work done, or the same product made, by using a less polluting process. Montana's pollution prevention activities have focused on assisting small businesses to comply with the National Ambient Air Quality Standards and the Maximum Achievable Control Technology requirements, both set by the federal Clean Air Act.

DEQ's Small Business Assistance Program provides businesses free and confidential technical assistance on pollution prevention and regulatory compliance to enable them to reduce and/or control their emissions of volatile organic compounds (VOCs), many of which are toxic, and other pollutants. For instance, automobile refinishing shops create VOC emissions through several processes, including spray coating and parts washing. DEQ has helped dozens of auto body shops increase their efficiency and reduce emissions by advising them of the benefits of energy efficient spray booths and heating systems. DEQ also has worked with dry cleaners, coatings manufacturers (makers of architectural, industrial, and automobile coatings and finish products), printing and publishing shops and a variety of small manufacturers doing metal fabrication, fiberglass manufacturing, and plastic injection molding.

In addition to its programs for small businesses, DEQ is working with cement plants and wood products manufacturers to identify industrial process changes or material substitutions that would eliminate certain air emissions, improve efficiency, and reduce waste generation. So far, work with the cement plants has been more successful with recycling projects (see below), although DEQ is exploring the possibility of one of the plants using some wood wastes as fuel. DEQ recently entered a partnership with Techlink, a research organization funded by NASA, to transfer energy efficient technologies to Montana's wood products industries. The wood products industry produces gaseous emissions, including hydrocarbons, aldehydes, VOCs, CO, SO_2, and NO_x. While the main goal of the project with Techlink is to reduce emissions of air toxics and other pollutants to protect human health, increased energy efficiency also reduces greenhouse gas emissions.

The Montana construction and demolition industries will be the target of a major technical assistance effort to prevent pollution and reduce greenhouse gas emissions. DEQ received a Climate Change Action Plan grant from EPA to research the availability and practicality of sustainable building products and practices for mainstream residential homebuilders. The goal of the project is to educate consumers and home builders about alternative materials, practices, and plans that reduce construction wastes (and associated fees for waste disposal) and the emission of greenhouse gases. The project will begin in fall 1999, and be completed by mid-2000.

Conclusion: DEQ should continue and expand its pollution prevention programs.

8.3 Recycling

Manufacturing recycled products usually takes less energy and releases less pollution than manufacturing products from raw materials. Recycling aluminum may be the best example of these emission reductions. Recycling also reduces potential emissions from landfills, and other environmental problems such as water pollution.

The Montana Integrated Waste Management Act of 1991 (MCA 75-10-802) directed state government to reduce, reuse, recycle, and compost waste materials whenever possible to lessen the impact on the environment and improve efficiency. The Act required the Department of Health and Environmental Sciences (now DEQ) to formulate an Integrated Waste Management Plan for source reduction and recycling. The 1994 plan called for Montanans to recycle 25 percent of their waste by 1996. Unfortunately, a lack of developed markets for recyclable goods and other limiting factors including transportation costs, lack of local end-users, and low recycled commodity prices made such a high recycling rate unachievable.[288] Montana's current 5 percent recycling rate is the lowest in the nation.[289]

DEQ will revise the Integrated Waste Management Plan by June 2000. The major areas covered by the new plan are creating markets for recyclable and recycled goods, assisting collection efforts, identifying end-users, and easing transportation challenges. Market development is one key element of DEQ's plan to increase Montana's recycling rate. Increasing the amount of recycled goods bought by government could play an essential role in developing local markets.

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[288] Livingston, Juliann. *Montana's Future in Recycling. A Geographic Study of Factors Contributing to the Viability of Recycling Municipal Solid Waste*. 1999. Master's Thesis, Montana State University, Bozeman, MT.

[289] Glenn, Jim. "The State of Garbage in America." *Biocycle*. Vol. 40, No. 4, 1999. pp. 60-71.

DEQ hired a market development specialist in 1999 to identify opportunities for source reduction, waste reuse, recycling, and composting for state government, private industry, and communities. The market development specialist educates businesses and individuals about the efficiency and cost savings of source reduction or recycling programs. The specialist also provides technical assistance to implement such programs.

DEQ provides technical assistance to communities interested in adopting volume-based waste disposal systems. The program is called “Pay as You Throw.” Each resident and business is charged for the volume of waste they generate. By making the price of landfilling waste more visible, the program encourages waste reduction and recycling by landfill users. “Pay as You Throw” has been adopted in five communities, including the city of Bozeman and the towns of Lincoln, Drummond, Philipsburg and Thompson Falls. It is also being considered for adoption in the city of Missoula.

The rural recycling and “Pay As You Throw” programs in Montana have been aided by the efforts of the Headwaters Recycling Cooperative, based in Boulder, Montana. This organization services collection facilities in nine counties (Broadwater, Gallatin, Granite, Jefferson, Lewis & Clark, Madison, Park, Powell, and Silver Bow). It provides recycling opportunities for rural residents who otherwise would have no choice but to dispose of their recyclable materials in their local landfills.

Altogether, there are over 100 collection facilities for recyclable materials in Montana, including the Headwaters Cooperative and several private waste management and recycling operations.[290] Additional information about recycling can be obtained from Keep Montana Clean and Beautiful, a trade association with members from the beverage, packaging, waste management and recycling industries and local government.

There have been some efforts to substitute waste glass for silica in road-building and construction material. Following discussions with DEQ in 1998, Ash Grove, one of the two Montana cement companies, started substituting 250 tons per year of waste glass for a portion of the silica used at its plant. This both saves landfill space and requires less extraction of raw material. Discussions with Holnam, the other cement manufacturer, recently led to its agreeing to substitute 800 tons per year of waste glass for silica. These experimental projects may pave the way to greater use of waste glass. Holnam plans to gradually increase its consumption of waste glass to more than 2000 tons per year. Bozeman, Great Falls and Missoula are using recycled glass as the “base course” under asphalt roads, as bedding and backfill for sewers and culverts and in other uses in place of gravel.

Conclusion: Montana communities could increase recycling and decrease solid waste volumes by adopting volume-based waste disposal charges. State government could use its purchasing power to build the market for recycled products. DEQ should continue to develop local and regional markets for recyclable materials.

[290] Montana Recycling Directory 1998. Keep Montana Clean and Beautiful, Helena, MT.

8.4 Landfills

Montana's landfills produce both CO_2 and methane through the decomposition of organic materials. Landfills also produce other greenhouse gases, including Freons from propellant gases in aerosol cans and spent appliance and equipment coolants, and VOCs from a variety of hazardous wastes.

About 93 percent of Montana's waste is landfilled.[291] In calendar year 1997, Montanans disposed of 959,680 tons of waste in 31 municipal solid waste landfills. Fifty percent of that waste went to just three facilities, Billings, Great Falls and Missoula. The next five largest landfills took another 27 percent. The other 23 landfills handled the last 23 percent. The largest landfill, serving Billings, received 218,015 tons of refuse. The smallest municipal landfill in the state, at Broadus, took in only 595 tons of refuse. Only the three largest landfills handled more than 100,000 tons per year.

The probability of the beneficial use of methane at Montana landfills is slight, unless substantial economic incentives are offered. Most landfills are remote from potential users, are small, and do not generate sufficient methane in Montana's dry and cold climate to be economical sources of energy. Most do not even justify an extraction and flare system. There are no landfills in Montana burning methane for heat or generating electricity. Three landfills extract and flare methane gas (Missoula, Bozeman, and Flathead). They do so because of potential explosive gas problems at the facility's boundaries. They extract 300 to 600 cubic feet per minute of landfill gas from their landfills. The gas quality is around 50 percent methane. Three others (Helena, Butte, and Billings) vent methane from their facilities directly to the atmosphere.

DEQ requires each of Montana's 31 landfills to be licensed so that the type and volume of incoming materials can be monitored. The three landfill flares are also permitted by DEQ to allow the agency to keep an inventory of the emissions from those facilities and make them subject to certain operating requirements.

In 1997, the Flathead County landfill in Kalispell installed a household hazardous waste storage unit to provide its customers with a safe place to bring their used paint, solvents, and refrigerants. It is the only Montana landfill to control VOC emissions in such a fashion. The unit is explosion proof, leak proof, and ventilated. The landfill contracts with a hazardous waste management company to transport these materials to a licensed disposal facility. The hazardous waste storage unit keeps these materials from contaminating other areas of the landfill and provides the public with the option of hazardous waste management instead of disposal. This also helps to reduce emissions of greenhouse gases from hazardous waste materials that otherwise might be illegally dumped. This approach is more cost-effective than the household hazardous waste collection days that some communities in Montana have sponsored.

All Montana waste management facilities have procedures for insuring the removal of Freon from appliances at a moderate cost to the consumer. Unattended rural container sites receive occasional midnight dumping of Freon containing appliances, but this accounts for only a small proportion of the total number of appliances in Montana. Freon is a form of chlorofluorocarbon (CFC). CFCs are not included among greenhouse gases to be controlled under the Kyoto

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[291] Glenn, Jim. "The State of Garbage in America." *Biocycle*. Vol. 40, No. 4, 1999. pp. 60-71.

protocol, but they do have some greenhouse effect, along with their better known effect on the ozone layer.

Conclusion: DEQ should encourage Montana communities to install hazardous waste collection units at the landfills.

CHAPTER 9: AGRICULTURAL SECTOR

9.1 Introduction

Montana's agricultural sector, as in many states, is a significant source of greenhouse gases. Methane (CH_4) and nitrous oxide (N_2O) from livestock and nitrous oxide from fertilizer accounted for about 12 percent of the inventoried emissions in Montana.[292] Both gases are far more effective at trapping heat than is carbon dioxide: a unit of methane is equivalent to 21 of carbon dioxide, and a unit of nitrous oxide is equivalent to 310 of carbon dioxide.

In one sense, emissions from the agricultural sector are not much different from natural emissions. For instance, methane from cattle has replaced methane from buffalo. Nitrous oxide can be emitted through the natural process of plant decay as well as from fertilizer. However, because the amount of emissions per unit of grain or meat produced is a result of human decisions, it is appropriate to include agricultural emissions in a greenhouse gas action plan. Greenhouse gas emissions can be reduced primarily by continuing and expanding what already are recognized as good practices to reduce the cost of production and improve water quality. Further elaboration of these practices would best be done by people familiar with Montana conditions, those people working agricultural and livestock operations and the university and government specialists that assist them.

9.2 Enteric fermentation

Methane from livestock makes up almost 10 percent of the inventoried greenhouse gas emissions in Montana. In Montana, beef cattle accounted for over 90 percent of the animal methane emissions inventoried in 1990. Methane is produced as part of the normal digestive process in any animal that eats plants. Changes in feed can affect the amount of methane produced, making this a potentially valuable strategy on the national level. However, this strategy will be of limited use in Montana, where most cattle are on pasture and range. Instead, efforts to reduce the

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[292] Agricultural operations emit carbon dioxide from equipment using gasoline and diesel fuel. The inventory included these emissions with those from the commercial sector.

Carbon dioxide emissions also are caused by the amount and type of tillage used. Emissions associated with tillage were not included in the inventory, with the exception of conversions of farmlands to grasslands. Therefore, changes in tillage methods—such as converting to no-till—are not included in the action plan. However, presentations at a recent national conference sponsored by the Montana Carbon Offset Coalition (see p.149) ("Exploring Opportunities for Carbon Sequestration, October 26-28, 1999, in Missoula) identified substantial emissions that can be caused or avoided by different tillage methods.

amount of feed per unit produced may be the best way in Montana to reduce overall methane emissions from livestock.

The amount of methane produced and excreted by an individual animal depends primarily upon the animal's digestive system, and the amount and type of feed it consumes. The volume of methane produced from the digestive process (enteric fermentation) is largest in those animals that possess a rumen, or forestomach, such as cattle, sheep, and goats. The forestomach allows these animals to digest large quantities of cellulose found in plant material. This digestion is accomplished by microorganisms (methanogenic bacteria) in the rumen. These bacteria produce methane while removing hydrogen from the rumen. The majority (about 90 percent) of the methane produced by the methanogenic bacteria is released through normal animal respiration and belching (eructation).[293] The remainder is released as flatus. In addition to the type of digestive system, the quantity and quality of an animal's feed intake also affects methane volumes. In general, a higher feed intake leads to higher methane emissions. Feed intake is positively related to animal size, growth rate, and production (e.g., milk production, wool growth, pregnancy, or work). Therefore, feed intake varies among animal types as well as among different management practices for individual animal types.

The general strategy for reducing methane emissions is to breed and feed livestock to maximize energy efficiency. The more of the carbon in the feed that goes toward milk and meat production, the less energy will be wasted as methane. Programs that promote faster conception and easier repeat breeding the following year, higher calving percentages and heavier weaning weights will reduce the amount of methane produced per pound of beef ready for shipping.[294] More importantly, from a rancher's perspective, reducing methane emissions reduces the per unit costs of production.

Feed-based programs could play some role in reducing the amount of methane produced by the Montana livestock industry. The Montana Agricultural Experiment Station over the years has developed grain varieties that have superior feedlot performance.[295] Other research has shown that feed given pregnant cows can affect calf growth and survival.[296] These types of programs, though unlikely to be as significant in Montana as elsewhere in the country, nonetheless decrease the amount of methane emitted per unit of meat delivered to market.

EPA and USDA have supported research on methane generation in animals. Researchers are refining methane emissions estimates, identifying nutritional deficiencies, testing candidate

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[293] Energy Information Administration. Emissions of Greenhouse Gases in the United States 1997. October 1998. P.95.

[294] These practices may increase the amount of methane each animal releases, but they should drop the amount of methane per unit output.

[295] A recent example is "Valier" barley. In field trails, calves fed Valier gained weight 10 percent faster than their half-siblings fed either "Lewis" or "Baronesse." Valier also outyielded the most commonly grown barley variety in Montana by 10 percent. Jerry Bergman, Montana Agricultural Experiment Station, Sidney, Montana, personal communication with Paul Cartwright, DEQ, August 16, 1999.

[296] For instance, supplemental dietary fat given to pregnant dams might increase calf survival rates. See, M.A. Lammoglia et al. "Effects of Prepartum Supplementary Fat and Muscle Hypertrophy Genotype on Cold Tolerance in Newborn Calves." *Journal of Animal Science.* Vol.77, p.2227-2233. 1999.

management options for production performance and methane emissions reduction potential and documenting the economics of emissions reduction. Universities participating in these studies have included Washington State University, Utah State University, University of Tennessee, University of Georgia, and University of Southwestern Louisiana

Conclusion: Reducing the amount of feed necessary per unit of production from livestock can reduce greenhouse gas emissions.

9.3 Manure management

The management of livestock manure produces methane and nitrous oxide emissions. Methane is produced by the anaerobic decomposition of manure. Nitrous oxide is produced from the nitrogen in livestock manure and urine.

When manure is handled as a solid (e.g., in stacks or pits) or deposited on pastures and rangelands, it tends to decompose aerobically and produce little or no methane. As noted above, manure in Montana is mostly deposited naturally on pasture and range. However, DEQ estimates approximately 300 livestock production operations confine cattle numbering from several hundred to several thousand head.[297] Most of these operations handle manure in a dry feedlot system, where the animals are kept in unpaved confinement. At periodic intervals, the dried manure is hauled out and often is applied to fields.

In recent years, Montana has seen construction of several large-scale confinement operations, mostly for hogs. While these have the potential to create local water quality problems and air quality complaints, they are not currently major sources of greenhouse gases.

Manure can be substituted for synthetic fertilizer in some instances, which reduces net greenhouse gas emissions. Proper handling of manure can reduce the possibility of creating other environmental problems while reducing greenhouse gases. Odors from manure applications can be a problem near urban areas; however, these can be minimized by rapid incorporation of manure into the soil. Using composted instead of raw manure can produce better results.[298] Manure can be a fertile source of seeds and can include weeds; composting usually, though not always, removes this problem. Well-managed compost operations usually do not themselves cause methane emissions, because they typically maintain

[297] This estimate was made August 1999 by Tim Byron, DEQ, based on a survey conducted by a contractor in 1993 and on the experience of the Montana Pollutant Discharge Permit Program. Most these confined operations are on the smaller side.

[298] Reclamation of mined areas is a specific example of uses for which manure may be inappropriate. Studies conducted in Butte found uncomposted manure from feedlots to be an inferior source of organic material for use in mined land reclamation. Phosphate and nitrate levels were higher than optimal for the revegetation project. Manure also decomposed rapidly, and most of the organic carbon left the soil as CO_2. Richard Prodgers. "Butte Hill Revegetation Monitoring." Bighorn Environmental, prepared for Butte/Silver Bow Planning Department. February 1999. Pp.28-30.

an aerobic environment with proper moisture content to encourage aerobic decomposition of the materials. Even if methane is generated in anaerobic pockets in the center of the compost pile, the methane is most likely oxidized when it reaches the oxygen-rich surface of the pile.[299]

Conclusion: Employing management practices that use manure as fertilizer while minimizing environmental impacts can reduce greenhouse gas emissions.

9.4 Fertilizer

In Montana, synthetic fertilizer accounted for over 2 percent of the total inventoried greenhouse gas emissions.[300] The use of nitrogen-based synthetic and organic fertilizers for improved crop production generally increases emissions of nitrous oxide, unless application precisely matches plant uptake and soil capture.[301] Efforts to reduce the amount of fertilizer used will probably be driven by farmers' desires to reduce the cost of production and by concerns about air and water quality.

Nationally, synthetic nitrogen fertilizers account for 40 percent of the nitrous oxide released. In addition to reducing the ability of the atmosphere to radiate heat into space, nitrous oxide weakens the ability of plant communities to remove carbon dioxide from the atmosphere and store it. However, most public and regulatory attention is focused on the effects of excess nitrogen on water and air quality.[302] Excess nitrogen causes algae blooms in surface water and can be toxic to those who drink surface or ground water contaminated with nitrates. Certain types of algae may produce toxins that have been known to kill cattle and threaten humans that consume the water. Nitrate concentrations over 10 mg/l in surface or ground water are particularly toxic to the human fetus and infants, causing the condition known as methemoglobinenemia. In the air, compounds of nitrogen contribute to regional haze, ozone, and acid rain.

Fertilizer is a major cost of operating for farmers. Fertilizer application one season can affect yields the following year from the next crop in the rotation. USDA is promoting the development of "nutrient management plans" for farms and ranches and has produced new technical guidance on using fertilizer and manure more efficiently. It is working with EPA to require it on larger confined animal feeding operations as a part of the new federal initiative, the Clean Water Action Plan.

One of the more promising new methods to reduce fertilizer and other expenses is precision agriculture. Global positioning systems (GPS), which use satellites to determine precise locations on the ground and provide detailed soil nutrient content monitoring, can help farmers

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[299] U.S. EPA. Greenhouse Gas Emissions From Management of Selected Materials in Municipal Solid Waste. 1998. p.72.

[300] This estimate is based on the assumption that, on average, 1.17 percent of the nitrogen applied as fertilizer is released in the atmosphere as nitrous oxide. The actual percentage lost varies among operations.

[301] A.F. Bouwman, "Exchange of Greenhouse Gases Between Terrestrial Ecosystems and the Atmosphere, ' in A. F. Bouwman (ed.) *Soils and the Greenhouse Effect*. John Wiley and Sons, 1990.

[302] Many of the water quality problems of excess nitrogen actually are caused by urban lawn fertilizers and septic tanks.

better match fertilization to yield potential. This can mean increasing fertilizer applications in some portions of a field, but more often it results in decreased fertilizer use. One particularly successful user of a GPS system reported reducing his fertilizer application by 40 percent while increasing yields.[303] The Precision Agriculture Research Association (PARA), an association of producers, university experts and industry, has formed to promote site-specific methods for improving agriculture, including reducing fertilizer application.

In the future, Total Maximum Daily Loads (TMDLs) may be developed for nitrogen from non-point sources like agricultural operations in some watersheds. TMDLs essentially determine how much pollution a waterbody can handle and remain within state water quality standards, then—on a watershed wide basis—allocate portions of that load to each polluting source. On a few waterbodies, agricultural nitrogen has contributed to a water quality problem that must be addressed by setting a TMDL.[304] To restore water quality, municipal and industrial wastewater facilities on listed waters must reduce the amount of pollutants they discharge and nonpoint sources in those areas must implement best management practices (BMPs). These BMPs can include, but aren't limited to, reducing the amount of fertilizer used and improving manure management practices. Point sources and nonpoint sources in the Upper Clark Fork Basin are implementing a plan to reduce total nitrogen by approximately 80 kilograms per day during critical low flow period. TMDL planning efforts for nitrogen and phosphorus are now underway in the Flathead Lake watershed and in the Swan Lake watershed.

Conclusion: Optimizing crop nutrient-use efficiency through proper management practices can reduce greenhouse gas emissions. DEQ should, where appropriate, continue the development of Total Maximum Daily Loads (TMDLs) for agriculturally-based nitrogen sources.

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[303] "GPS touted as smarter way to farm." *Great Falls Tribune*. July 25, 1999. P.6b.

[304] The development of TMDLs is authorized by the federal Clean Water Act and 1997 amendments to Montana's Water Quality Act. DEQ must develop water quality restoration plans for each water body on the "impaired and threatened waters list." There are about 800 waterbodies on this list. A portion of the waterbodies is impaired due to nutrients such as nitrogen. All waterbodies on the list must have plans in place by the year 2007.

CHAPTER 10: CARBON SEQUESTRATION

Previous chapters of this report focus on reducing greenhouse gas emissions. An alternative approach is to remove carbon dioxide, the main greenhouse gas, from the atmosphere through a process known as "sequestration." In this process growing plants, especially trees, remove carbon dioxide from the air, incorporate the carbon into their tissues, and give off oxygen. Carbon bound up in plants remains out of the atmosphere until the plant dies and decays or is burned. Most trees have a natural life of 50 to 100 years.

Sequestration in vegetation cannot offset all greenhouse gas emissions. Montana would need to more than double the present area of its forestland to offset its emissions. This is unlikely. Sequestration in vegetation is not a permanent solution to the greenhouse gas problem; it delays emissions but does not eliminate them. What sequestration can do is buy time for people to change the economy and their lifestyles in ways that reduce carbon emissions. However, questions remain about the cost, technical effectiveness, and administrative problems involved in certifying that carbon emissions have been offset by carbon sequestration.

10.1 How carbon is sequestered

Carbon has always been removed from the atmosphere, or sequestered, by natural processes. The amount of carbon dioxide in the atmosphere actually climbs and falls as the northern hemisphere, where most land vegetation grows, goes through the seasons. Carbon dioxide is absorbed in the ocean waters and used by marine plants and animals. That carbon eventually is incorporated in ocean sediments, where it is locked up until geologic changes bring it to the surface again.

A wide range of methods for increasing the sequestration of carbon dioxide have been proposed, from tree plantations to geologic and deep ocean disposal. These are discussed in an U.S. Department of Energy (DOE) review of the state of the science of carbon sequestration.[305] DOE is working to determine whether affordable, reliable and safe carbon sequestration concepts can be readied for widespread commercial use by 2025. DOE is funding experimentation and technical and economic assessments of 6 research ideas on carbon sequestration, to be followed by pilot- and large-scale testing of the most promising approaches. Even with all these possibilities, the growing of plants is currently the only practical way to remove large volumes of carbon dioxide from the air.

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[305] U.S. Department of Energy. *Carbon Sequestration: State of the Science.* April 1999.

Reforestation, planting new forests (aforestation), improved management practices in existing stands, urban forestation, improved rangeland management and adoption of no-till agricultural practices are ways to increase the sequestration of carbon in biomass. Much of the work on sequestration has focused on planting and maintaining trees in forests. One acre of Douglas fir after 65 years of growth incorporates an estimated 600 to 700 tons of carbon dioxide.[306] Maximizing carbon storage is not the same as maximizing timber. Cutting older stands and replacing them with faster growing new trees is not the best way to sequester carbon. Logging older timber can damage the soil and forest floor storage of carbon. Usually, older stands sequester more carbon than younger ones, when all the biomass on the forest floor and in the soil is counted. This is an issue of some controversy because of its implications for logging policy.

In general, agricultural lands store less carbon than forestlands. Sequestering carbon in agricultural lands is less certain than in forests because the application of commercial fertilizer, manure or irrigation water can generate more carbon dioxide than is sequestered by the plants.[307] Nonetheless, the continuing change in tillage practices used by American farmers means American farms now are increasing rather than decreasing the amount of carbon in the soil.[308]

The benefits that accompany planting for carbon sequestration are likely to drive the initial interest in carbon sequestration projects. Trees decrease soil erosion, increase the water holding capacity of soil, and improve wildlife and fisheries habitats, all of which improve water quality. Since soil erosion itself releases carbon, tree planting on marginal agricultural land has a double benefit. Urban tree planting reduces energy use by cooling neighborhoods.[309] In some instances, tree planting can help eliminate the need for air conditioners and the release of chlorofluorocarbons (CFCs)[310] that accompanies their use.

Since carbon dioxide mixes throughout the atmosphere around the world, a sequestration project need not be located adjacent to the source whose emissions it is offsetting. Some have argued that sequestration projects should be located in areas, such as the tropics, where plants grow quickly. Projects in such areas can have additional and important social benefits. Others have argued that projects should be located in areas having legal and regulatory structures, such as the U.S., that can guarantee projects will sequester carbon as long as promised.

The viability and effectiveness of tree planting programs in sequestering carbon (their permanence) will depend to a large degree on how well the plantings survive. Potential projects need to be evaluated on a variety of criteria, such as the type of land to be planted and the length of the rotation (the average age of the trees at each harvesting cycle). Evaluations have to

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[306] PacifiCorp. *In the Forefront.* Portland Oregon, 1998.

[307] William Schlesinger. "Carbon Sequestration in Soils." *Science*. Vol. 284, p.2095. June 25 1999.

[308] Based on research by Raymond Allmaras, a soil scientist with the U.S. Agricultural Research Service, as reported in a Department of Agriculture press release, May 17, 1999.

[309] NASA conducted studies of urban heat islands in 1997 and 1998. Built-up areas are far better heat collectors than vegetated areas. For instance, mid-day surface temperatures in vegetated areas in Salt Lake City were around 70° F cooler than unshaded built-up areas.

[310] Freon is one example of a CFC.

account for possible failures to plant according to projections and for losses from forest fires and pests.

The most contentious issues, however, are administrative. In order to offset emissions, the sequestration must be greater than would occur naturally or that property owners would do on their own. This question of "additionality" is a central one in international negotiations. Establishing additionality will require some form of verification and on-site inspections. Monitoring the forest over a long timeline, such as an 80-year rotation, might be necessary. In order to obtain financing, projects will need some mechanism for linking the carbon sequestered in one spot to the emissions at another. This will require development of a market in carbon credits.

The urgency for establishing this market depends on the likelihood of national or international obligations to reduce carbon emissions and the acceptance of sequestration as a way to offset those emissions. Such acceptance is not yet guaranteed.

10.2 Existing carbon sequestration projects

Using forestry projects to offset the carbon dioxide emissions of a power plant was first tried in 1989. Applied Energy Services, an independent generating company, contributed to a sustainable forestry project in Guatemala to offset carbon dioxide emissions of its new 183 MW coal-fired electric plant in Connecticut. The project was carried out with technical assistance from the World Resources Institute (WRI). The project included planting about 30,000 acres of community woodlots, mostly in pine and eucalyptus for poles and lumber; implementing agroforestry practices on some 148,000 acres of agricultural land for fuel wood, fodder, soil nitrogen-fixation, and fruit and nut production; planting 1,800 miles of live fencing; building terraces to protect 5,000 acres of vulnerable slopes; and providing training and extension for community forest fire brigades to protect the newly planted trees and natural forests.

Since then, a number of other projects have been started. A WRI database shows that at least five sequestration projects are underway in the western U.S. Of these, PacifiCorp has sponsored three of these. (Unfortunately for sequestration efforts in Montana, PacifiCorp no longer serves any part of the state.) At this stage, the projects are only demonstrations of what could be done; none of them sequesters more than a fraction of the carbon dioxide emitted by the sponsor. Oregon's adoption in 1997 of a law authorizing a carbon dioxide standard for new energy facilities could inspire more projects in the region in the future. The Oregon standard allows companies to offset their emissions, including by sequestering carbon.

SEQUESTRATION PROJECTS

Project / Partners / Components	Carbon Sequestered Over the Lifetime of the Project	Cost
Pacific Forest Stewardship UtiliTree Carbon Co., Pacific Forest Trust, Oregon State University Improved forest management and conservation easements	242,082 tons	Less than $1.00 per ton
Reforestation in Eastern Washington Tenaska Inc., PacifiCorp, Trexler and Associates Reforestation	250,000 tons	$2.00 per ton
Forest Resource Trust Carbon Offset Project PacifiCorp, Forest Resource Trust, Trexler and Associates Reforestation	45,000 tons	Less than $2.00 per ton $75,000 total
Southern Oregon Reforestation PacifiCorp, Trexler and Associates Reforestation	66,150 tons	$2.00-2.50 per ton
Western Oregon Carbon Sequestration Project UtiliTree Carbon Co., Trexler and Associates, Oregon Woods, Inc., participating landowners Aforestation and sequestration in wood products	564,000-747,000 tons	Less than $1.00 per ton

Source: World Resources Institute, webpage, July 1999.

10.3 Carbon sequestration in Montana

There are opportunities for sequestration projects in Montana. An estimated 2.5 million acres or one-third of private forestlands in Montana are poorly stocked or non-stocked.[311] The high cost of planting trees, on-going management costs, and the long-term nature of the investment (up to 80 years) have dampened interest in many potential forestry projects. In 1997, a coalition of conservation and rural development groups formed to promote sequestration projects in Montana. The Montana Carbon Offset Coalition includes the Northwest Regional Resource Conservation and Development Area, Inc. (RC&D), the Bitterroot RC& D, the Headwaters RC&D, the Confederated Salish and Kootenai Tribes, and Montana Watershed Inc. (MWI). In addition to the principal coalition members, other interests represented by members include the Montana Nursery Association and the Montana Logging Association. Technical assistance is

[311] U.S. Forest Service Intermountain Research Station Bulletin INT – 81. September 1993. P.7.

being provided by the Natural Resources Conservation Service (NRCS) and the Montana Department of Natural Resources and Conservation (DNRC).

The coalition is trying to create a new marketable commodity from private forestlands. The coalition would provide financial and technical assistance to landowners in return for the rights to the sequestered carbon. The coalition then would market the carbon credits to investors seeking to offset carbon emissions. Easements secured with tree planting and maintenance agreements would require landowners to sign and register a carbon offset agreement as a conservation easement for a predetermined period of time. If the trees were harvested prior to the agreed harvest date, all financial compensation must be repaid. If the stand were harvested after the agreed date, the landowner would keep all compensation.

The coalition, in July 1999, received a renewable resources grant from DNRC to establish a pilot carbon offset program. This grant was approved by the Legislature. The project will provide corporate partners an opportunity to invest in a carbon offset program in Montana to demonstrate to forest landowners and policymakers the viability of forestry-based carbon offset projects. The coalition, in cooperation with a corporate partner, will provide cost share funding for tree planting or management activities on eligible private forestlands.[312] The proposed pilot program includes an urban forestry project to provide cost share and technical assistance to applicant communities to establish urban forestry programs on city-owned lands. For the first two years of the program, the coalition will fund up to 75% of materials.

On the strength of its in-state activities, the Montana coalition helped form a Pacific Northwest Carbon Sequestration Coalition in June 1998. Members of the PN Coalition include private, public and non-profit organizations from Alaska, Hawaii, Idaho, Washington and Montana. The regional coalition agreed to set uniform standards and protocols for calculating carbon sequestration credits for vegetation management and to establish systems to register certified credits.

10.4 What is to be done

Carbon sequestration projects could expand and enhance land stewardship programs already in existence. The sale of carbon credits would provide landowners revenue to replant and manage their forest stands while providing carbon offsets to companies seeking to sequester their emissions. When combined with USDA Natural Resources Conservation Service (NRCS) cost share programs, such as the Environmental Quality Incentives Program (EQIP) and the Conservation Reserve Program (CRP), carbon sequestration projects would allow farmers, forest landowners and ranchers to use conservation practices that previously were not feasible. Newer efforts, like the ones in many Montana cities to provide for open space in and around the urban area, would benefit by the sale of carbon credits.

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[312] Eligibility requirements are: 1) landowners must not have been enrolled in any tree planting or management activities, and 2) the project must be conducted on a minimum of 10 acres and a maximum of 50 acres per landowner per year.

However, Montana carbon credits will be worthless without being tradable and without a market in which they could trade. The coalition, through its pilot project, will explore how contracts should be structured and will develop a protocol for carbon trading, including establishing how carbon credits will be certified. Much as is the case with organic food, carbon credits will only command a price if the buyers are confident that the product is genuine. Either some private organization or state government will need to set and guarantee standards for Montana Certified Carbon Credits.

A market for carbon credits cannot be established at the state level. That will depend on the actions, or at least the expectation of action, by national governments, either individually or through international treaty. Such an expectation led the Sydney Futures Exchange, and its subsidiary, the New Zealand Futures and Options Exchange, to announce in August 1999 their intent to open the world's first market for sequestered carbon. This will allow world industry to buy carbon dioxide absorbed by new forests to offset against the gas emitted by industry.

Guarantee of future credit for voluntary actions undertaken now to reduce carbon emissions will increase the interest of the private sector in carbon credits. This guarantee has yet to be made. It's likely that conventions established now for carbon credits may change later, but projects as proposed by the coalition must be done now to determine what those conventions should be. By supporting and following up on the coalition's pilot project, Montana will be able to influence how carbon credits will work.

Conclusion: A state or private certification procedure to track and record carbon credits created in Montana is a necessary condition for a carbon market to emerge. Establishing national voluntary early action carbon credits would assist in the development of pilot programs prior to mandatory national or international requirements.

CHAPTER 11: FUTURE GREENHOUSE GAS PROGRAM ACTIONS

This report has discussed areas where taking action would be attractive even if greenhouse gas emissions were not an issue. Actions likely to grow out of this report would be a first step, an effort to stop digging the hole deeper. They are more likely to slow the increase in Montana's greenhouse gas emissions than to cause an actual drop. For that to happen, Montanans must be willing to take far-reaching steps to restructure their economy. They must be willing to do so even though the benefits in terms of climate change may be more visible to their children than to themselves. Such comprehensive action will occur if the climate changes in ways that Montanans can't ignore, if avoiding climate change becomes a national priority or if the effort to reduce greenhouse gas emissions turns up unexpected improvements in the economy or the quality of life. Until that time, state government could take some modest actions on the assumption that controlling greenhouse gas emissions will be more an issue than is the case now.

11.1 Providing greenhouse gas information

Because the issue is unlikely to go away any time soon on the international level, Montanans can expect more and more individuals, corporations and organizations to be issuing statements on climate change and greenhouse gas emissions. State government can assess the ones bearing most directly on Montana and interpret the accuracy and effect of these predictions and positions. State government also can provide information on energy efficiency programs and technologies that are cost-effective now. DEQ already is taking some actions along those lines. Perhaps the easiest and least expensive way to provide information services for people concerned about greenhouse gas is to establish a greenhouse gas clearinghouse page as part of DEQ's website. In addition to Montana-specific information, this page could provide links to regional, national and international sources of information.

Conclusion: DEQ should establish and maintain a webpage with information about climate change and controlling greenhouse gas emissions.

11.2 Registering voluntary actions to reduce greenhouse gas emissions

At some point in the future, greenhouse gas emissions could become regulated pollutants. The federal government may well impose greenhouse gas emissions reduction requirements nationwide. In past air pollution reduction programs, the federal government has not always considered emissions reductions made prior to the implementation of such programs. Official recognition of early voluntary actions, prior to the implementation of any federal programs, would create an incentive for and reward to greenhouse gas sources that reduce emissions before being required to do so. In the absence of any federal program to establish such recognition, Montanans could still be protected through the creation of a state registry of voluntary early actions.

The purpose of such a registry would be to help sources establish a baseline against which any future federal greenhouse gas emissions reduction requirements could apply. The registry should cover any measures undertaken voluntarily to reduce greenhouse gas emissions below what otherwise have been the case under a "business as usual" approach. New Hampshire just authorized establishment of such a registry (see New Hampshire SB159). Other states, including Wisconsin and Connecticut, are discussing the possibility of such a registry. Options for a registry range from accepting self-certification of voluntary actions to independent engineering estimates of emissions reductions to rigorous monitoring of actual changes in emissions. The cost and complexity of maintaining a registry, as well as the likelihood that the voluntary actions will be recognized in the future, would depend which option was chosen.

Conclusion: DEQ should develop a proposal for a registry of voluntary actions to reduce greenhouse gas emissions below what otherwise would have been the case under a "business as usual" approach.

11.3 Mitigating the impacts of climate change

The purpose of acting now to reduce greenhouse gas emissions is to avoid the worst effects of climate change. It may be too late to totally avoid change in the climate. Because greenhouse gases remain in the atmosphere for so long, the total amount of greenhouse gases will continue to rise even if annual emissions stop growing. If the world returned emissions levels to those of 1994, the amount of CO_2 in the atmosphere would continue to increase at a near constant rate for at least two centuries. What this would mean in terms of Montana's climate still isn't certain. The beneficial consequences, if any, will take care of themselves. It's the detrimental consequences that state government will be expected to deal with.

Unless something drastic happens, such as the Gulf Stream shutting down, the impact of climate change probably will look like climate events with which Montanans are familiar, only more so: more drought, more weakening of the agricultural, ranch and timber industries, worse fires and fewer attractions for tourists. Climate change also will eventually induce large-scale population movements. Whether movements are into or out of Montana will depend on how the rest of the country and nearby nations fare.

The very uncertainty of the possible consequences makes planning mitigation strategies difficult in Montana. Montana has no readily identified mitigation strategies that are attractive in their own right. (In contrast, coastal states for instance can improve their seawalls, a mitigation strategy that has benefits even if climate change doesn't occur.) For now, government agencies that might be asked to mitigate the impacts on industries and activities affected by climate can only monitor the development of climate change science, and otherwise continue to do what they do. Such agencies would include, at minimum, the Departments of Agriculture; Livestock; Fish, Wildlife and Parks; Natural Resources and Conservation; the Disaster and Emergency Services Division; and the Travel Promotion and Development Division.

Conclusion: State agencies responsible for industries and activities potentially affected by climate change should monitor developments in climate change science.

ATTACHMENT 1:

WEBLINKS

This attachment lists all the weblinks embedded in the text. The links are organized by section by chapter. The right-hand column has the words that are linked in the text.

CHAPTER 1: BACKGROUND AND CONTEXT

1.2 Primer on greenhouse gas science	
EPA webpage	http://www.epa.gov/globalwarming/climate/index.html
The Science of Climate Change: Global and U.S. Perspectives	http://www.pewclimate.org/projects/env_science.html
Emissions of Greenhouse Gases in the United States 1997	http://www.eia.doe.gov/oiaf/1605/1605a.html?65,75
1.3 Some of the evidence	
Intergovernmental Panel on Climate Change	http://www.ipcc.ch/pub/reports.htm
Reanalysis	http://science.nasa.gov/newhome/headlines/notebook/essd13aug98_1.htm
Cooling in the mesosphere	http://www.newscientist.com/ns/19990501/chillinthe.html
Common Sense Climate Index	http://www.giss.nasa.gov/research/intro/hansen.04/
warmest decade of the millennium	http://www.umass.edu/newsoffice/press/99/0303climate.html
1998	http://www.giss.nasa.gov/research/observe/surftemp/
Shift in climate	http://www.cpc.ncep.noaa.gov/trndtext.htm
"When Meteorologists See Red"	http://www.sciencenews.org/sn_arc99/3_20_99/bob2.htm
Glacier Park	http://www.mesc.usgs.gov/glacier/glacier_model.htm
Ice shelves in Antarctica	http://www-nsidc.colorado.edu/NSIDC/ICESHELVES/lars_wilk_news/
1.4 Effect of climate change	
Cooling effect of sulfates	http://www.epa.gov/globalwarming/climate/trends/temperature.html
Presentation	http://www.pnl.gov/atmos_sciences/Lrl/index.html
Loss of trout habitat	http://www.epa.gov/globalwarming/greenhouse/greenhouse2/fish.html

1.5 Reasons for action	
The Great Climate Flip-flop	http://www.theatlantic.com/issues/98jan/climate.htm
Simulation of an abrupt change in Saharan vegetation in the Mid-Holocene	http://www.agu.org/pubs/toc/gl/gl_26_14.html
"The Coming Anarchy"	http://www.theatlantic.com/election/connection/foreign/anarchy.htm
Graphs for Montana	MT ghg compared to world.pdf (will be available at DEQ website)
Leadership and Equity: The United States, Developing Countries and Global Warming	http://www.envirotrust.com/climate.html
"Contributions to Climate Change: Are Conventional Metrics Misleading the Debate?"	http://www.wri.org/wri/cpi/notes/metrics.html
Climate Change 1995: The Science of Climate Change/Summary for Policymakers	http://www.ipcc.ch/pub/sarsum1.htm
Statement	http://www.pewclimate.org/council.html
Reports	http://www.munichre.com/press/press/981229_eng.htm
Kyoto Protocol	http://www.epa.gov/globalwarming/actions/global/index.html
World Resources Institute	http://www.wri.org/press/lancetnr.html
1997 Air Quality Trends Report	http://www.epa.gov/oar/aqtrnd97/toc.html
1.6 Greenhouse gas emissions in Montana	
Climate Change 1995: The Science of Climate Change/Summary for Policymakers	http://www.ipcc.ch/pub/sarsum1.htm

CHAPTER 2: TRANSPORTATION COST AND ALTERNATIVES

2.2.3 Related pollution	
study	http://www.arb.ca.gov/research/indoor/in-vehsm.html
2.3.1 Overview	
ISTP Publications	http://wwwistp.murdoch.edu.au/RESEARCH/PUBLICAT/pubstopics.html
2.3.4 Funding construction of major roads	
Implications for Recouping a Portion of the "Unearned	http://www.bts.gov/ntl/DOCS/borhar.html

Increment" Arising From Construction of Transportation Facilities	
2.3.9 Other variable pricing options: Cashing out parking	
Commuter Check Services Corp. (CCSC) website	http://www.commutercheck.com/
2.4.1 CAFE standards/efficient vehicles	
"Why CAFE Worked"	http://www.bts.gov/ntl/data/cafeornl.pdf
these cars (Hypercars)	http://www.hypercarcenter.org/
Partnership for a New Generation of Vehicles	http://www.ta.doc.gov/pngv/
2.4.3 Highway speed limits	
documented violations	http://www.epa.gov/oms/recall.htm
2.6 Alternative fuels	
fuel cells website	http://216.51.18.233/index_e.html
U.S. DOE website	http://www.afdc.doe.gov/refueling.html

CHAPTER 3: TRANSPORTATION AND URBAN DESIGN

3.5 Why urban design matters	
High Mileage Moms	http://www.transact.org/highmilemoms/splash.htm
Smart Growth Network	http://www.smartgrowth.org/
Study (growth in the Salt Lake City area)	http://www.envisionutah.org/index.html
Study (Chicago-area developments)	http://farm.fic.niu.edu/cae/scatter/e-loecov.html
ISTP Publications	http://wwwistp.murdoch.edu.au/RESEARCH/PUBLICAT/pubstopics.htm
3.6 What to do now	
Smart Growth	http://www.op.state.md.us/smartgrowth/index.html
Standards (Vermont Agency of Transportation)	http://www.aot.state.vt.us/projdev/standards/statabta.htm
SB97	http://161.7.127.14/bills/billhtml/SB0097.htm
3.7 Appendix: Induced traffic	
Relationships Between Highway Capacity And Induced Vehicle Travel	http://www.epa.gov/tp/trb-rn.pdf

Social Costs of Alternative Land Development Scenarios	http://www.ota.fhwa.dot.gov/scalds/
Victoria Transport Policy Institute	http://www.islandnet.com/~litman/
Traffic Impacts of Highway Capacity Reductions: Assessment of the Evidence	http://www.ucl.ac.uk/transport-studies/sc1.htm

CHAPTER 4: ELECTRIC UTILITY INDUSTRY AND ELECTRICITY USE

4.1 Introduction	
Emissions of Greenhouse Gases in the United States, 1997	http://www.eia.doe.gov/env/ghg.html
Benchmarking Air Emissions of Electric Utility Generators in the United States	http://www.nrdc.org/nrdcpro/inx/publ.html
State Electricity Profile	http://www.eia.doe.gov/cneaf/electricity/st_profiles/montana/mt.html
The Energy Project: Restructuring and the Electric Industry	http://www.ncsl.org/programs/esnr/restru.htm
4.3.1.5 “Truth In Labeling” activities – Environmental disclosure and state certification of green power	
U.S. DOE’s Green Power website	http://www.eren.doe.gov/greenpower/
Automated Power Exchange	http://www.energy-exchange.com/html/apx_green.htm
“Opportunities For Biomass In The APX Green Power Market.”	http://www.apx.com/biomass_paper.htm
4.3.2.3 Support for investments in distributed generating technologies	
Million Solar Roof	http://www.eren.doe.gov/millionroofs/
Greening of Yellowstone	http://www.greendesign.net/parks/
Wind Powering America	http://www.eren.doe.gov/windpoweringamerica/
4.3.3.1 Energy efficiency potential	
Northwest Power Planning Council	http://www.nwppc.org/welcome.htm
Montana Irrigation Management	http://www.mtim.org/
4.3.3.3 Direct use of USBC funds	
Northwest Energy Alliance	http://www.nwalliance.org/
4.3.3.4.2Energy service companies	
U.S. DOE’s Rebuild America Financial Services site	http://www.ornl.gov/rafs/rafs.htm

4.3.3.6 Consumer protection measures - building codes, inspection, and certification of energy consumption labels for structures	
Energy Star Building Program	http://www.epa.gov/appdstar/buildings/
Home Energy Saver	http://hes.lbl.gov/

CHAPTER 5: NATURAL GAS

5.2 Natural gas use in Montana	
Natural Gas 1998: Issues and Trends, 1999	ftp://ftp.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_trends/pdf/chapter2.pdf
State Profile	http://www.eia.doe.gov/cneaf/electricity/st_profiles/montana/mt.html
5.4 Factors driving future growth in natural gas use	
Annual Energy Outlook 1999	http://www.eia.doe.gov/oiaf/supplement/sup99b.pdf
5.5.2.1 Small furnace combustion efficiency	
. Table 3.15a. Space Heating by Census Region	http://www.eia.doe.gov/emeu/recs/recs97_hc/tbl3_15a.html
5.5.2.2 Ductwork	
Table 3.15a. Space Heating by Census Region.	http://www.eia.doe.gov/emeu/recs/recs97_hc/tbl3_15a.html
5.5.2.4 Market-based efficiency incentives	
Energy Star Homes	http://www.epa.gov/appdstar/homes/index.html
5.6 Fugitive methane emissions	
NICE3	http://www.oit.doe.gov/nice3/
Historical Natural Gas Annual 1930 through 1997	http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/historical_natural_gas_annual/hnga.html
Natural Gas STAR	http://www.epa.gov/gasstar/

CHAPTER 6: CARBON TAXES AND TRADABLE EMISSIONS PERMITS

6.1 Introduction	
"The Benefits and Costs of the Clean Air Act, 1970 to 1990,"	http://epainotes1.rtpnc.epa.gov:7777/opa/admpress.nsf/b1ab9f485b098972852562e7004dc686/ef494b0c753c5863852565370069dca4?OpenDocument
6.2.1 Merits of a carbon tax	
Emissions of Greenhouse Gases in the United States 1997	http://www.eia.doe.gov/oiaf/1605/1605a.html?25,78
6.2.3 Acceptability of a carbon tax	
Table 34. Receipts and Average Cost of Coal Delivered to Electric Utilities by Census Division and State	http://www.eia.doe.gov/cneaf/electricity/epm/epmt34.txt
Washington Department of Revenue	http://dor.wa.gov/
Analysis of Bonneville Power Administration's Future Costs and Revenues	http://www.nwppc.org/98_11.htm
6.3.3 Experience with tradable permits	
OECD climate change	http://www.oecd.org//env/cc/domestic_trading.htm
"SO2 Permit Trading: How Experience and Expectations Measure Up"	http://www.rff.org/disc_papers/PDF_files/9724.pdf
EPA's website	http://www.epa.gov/acidrain/article.htm
EPA Acid Rain Program Overview website	http://www.epa.gov/docs/acidrain/overview.html
6.3.4 Feasibility of a tradable carbon emissions permit program in Montana	
The Effects of Title IV of the Clean Air Acts Amendments of 1990 on Electric Utilities: An Update.	http://www.eia.doe.gov/cneaf/electricity/clean_air_upd97/exec_sum.html

Chapter 7: MAJOR INDUSTRIAL SOURCES

7.1 Overview	
EPA's website	http://www.epa.gov/ttn/uatw/
Voluntary Aluminum Industrial Partnership	http://134.67.55.16:7777/DC/Methane/HOME.NSF/pages/vaip
BP Amoco	http://www.bpamoco.com/_nav/hse/index_climate.htm

Chapter 8: WASTE MANAGEMENT

8.1 Introduction	
Greenhouse Gas Emissions From Management of Selected Materials in Municipal Solid Waste	http://www.epa.gov/mswclimate/tools.htm
EPA's website	http://www.epa.gov/mswclimate/
8.3 Recycling	
Keep Montana Clean and Beautiful	http://www.recyclemontana.org/

CHAPTER 9: AGRICULTURAL SECTOR

9.2 Enteric fermentation	
Emissions of Greenhouse Gases in the United States 1997	http://www.eia.doe.gov/oiaf/1605/1605a.html?103,83
Washington State University	http://www.ansci.wsu.edu/facilities/beef.center/
9.4 Fertilizer	
Greenhouse Gas Emissions From Management of Selected Materials in Municipal Solid Waste	http://www.epa.gov/mswclimate/tools.htm
Clean Water Action Plan	http://www.cleanwater.gov/
Precision Agriculture Research Association	http://stone.msu.montana.edu/para/
Total Maximum Daily Loads	http://www.deq.state.mt.us/ppa/tmdl_wel.htm

CHAPTER 10: CARBON SEQUESTRATION

10.1 How carbon is sequestered	
state of the science of carbon sequestration	http://www.fe.doe.gov/coal_power/sequestration/index.html
6 research ideas	http://www.fetc.doe.gov/publications/press/1999/tl_seq2.html
press release	http://www.ars.usda.gov/is/pr/1999/990517.htm
studies	http://science.msfc.nasa.gov/newhome/headlines/essd21jul98_1.htm

10.2 Existing carbon sequestration projects	
database	http://www.igc.org/wri/wri/wri/climate/mitigate.html
carbon dioxide standard	http://www.energy.state.or.us/climate/climhme.htm
webpage	http://www.igc.org/wri/wri/wri/climate/mitigate.html
10.4 What is to be done	
world's first market	http://www.sfe.com.au/Presentation/home/

CHAPTER 11: FUTURE GREENHOUSE GAS ACTIONS

11.2 Registering voluntary actions to reduce greenhouse gas emissions	
SB159	http://www.state.nh.us/gencourt/bills/99bills/sb0159.html

ATTACHMENT 2:

PARTIAL LIST OF RESEARCH PROJECTS RELATED TO CLIMATE CHANGE BEING CONDUCTED BY MONTANA SCIENTISTS

October, 1999

(Note: In some cases the funding amount listed is for the current award period only and does not reflect the total dollar amount for the full duration of the project.)

PROJECT TITLE: Changes in Adelie Penguin Populations at Palmer Station: The Effects of Human Disturbance and Long-Term Environmental Change

INVESTIGATOR/ORGANIZATION: William R. Fraser, Department of Biology, Montana State University

FUNDING AGENCY: National Science Foundation

FUNDING AMOUNT: $331,115

DURATION: August 15, 1995 through July 31, 1999

DESCRIPTION: Recent research based at Palmer Station, Antarctic Peninsula, indicates that Adelie Penguin populations on Litchfield and Torgersen islands decreased by 43% and 19% respectively, between 1975 and 1992. The lack of correspondence between human activity and Adelie Penguin population decreases on these two islands suggests that the potentially adverse effects of human activity may be difficult to measure relative to the effects imposed by long-term change in other environmental variables. The purpose of this research is to incorporate a human impact study within the scope of work currently underway at Palmer Station as part of two large ecosystem-level research programs. The results of this research are expected to support the idea that Adelie Penguin populations occur in “sink” (the population is not self-maintaining over ecological time) and “source” (the population is self-maintaining over ecological time) habitats. Being able to differentiate between sink and source populations has important implications to research concerned with climate change, fisheries-related monitoring studies, human disturbance and the management of human activity in Antarctica.

PROJECT TITLE: Workshop on Antarctic Seabird Population Trends

INVESTIGATOR/ORGANIZATION: William R. Fraser, Department of Biology, Montana State University

FUNDING AGENCY: National Science Foundation

FUNDING AMOUNT: $7,000

DURATION: May 15, 1999 through April 30, 2000

DESCRIPTION: Long-term studies on changes in Antarctic and sub-Antarctic seabird populations are presently emerging as important tools for monitoring the effects of human activity, and for understanding and modeling interactions between climate change and ecosystem responses. This award provides partial support for an international workshop with the following objectives: to identify and catalogue existing long-term databases on Antarctic and sub-Antarctic seabird populations, to subject the extant data to rigorous statistical analysis with the aim of determining the scope, magnitude and significance of the population trends, and to disseminate the results to relevant Antarctic scientific working groups and the general research community.

PROJECT TITLE: Seabird Investigations in the Antarctic Marine Environment as part of the 1997-1998 Antarctic Field Research

INVESTIGATOR/ORGANIZATION: William R. Fraser, Department of Biology, Montana State University

FUNDING AGENCY: S.W. Fisheries Center

FUNDING AMOUNT: $40,010

DURATION: October 1, 1997 through September 30, 1998

DESCRIPTION: Abstract requested.

PROJECT TITLE: Long-Term Ecological Research of the Antarctic Marine Ecosystem: An Ice Dominated Environment

INVESTIGATOR/ORGANIZATION: William R. Fraser, Department of Biology, Montana State University

FUNDING AGENCY: University of California

FUNDING AMOUNT: $326,183

DURATION: October 1, 1996 through September 30, 1999

DESCRIPTION: The Antarctic marine ecosystem, the assemblage of plants, animals, microbes, ocean, sea ice and island components south of the Antarctic Convergence, is among the largest readily defined biomes on Earth. Oceanic, atmospheric, and biogeochemical processes with this system are thought to be globally significant, have been infrequently studied and are poorly understood relative to more accessible marine ecosystems. Like most marine food webs, the trophic relationships in Antarctica are complex. The general sampling approach in this study capitalizes on the close coupling between tropic levels, the limited number of species involved, and the fact that one of the dominant predators is seabirds that nest on land and are thus easily accessible during the spring and summer breeding season. An important apex predator is the Adelie Penguin, which dominates the seabird assemblage near Palmer Station in terms of abundance and biomass. Solar radiation, atmospheric and oceanographic as well as sea ice coverage are the physical forcing mechanisms driving variability in biological processes at all trophic levels in Antarctica.

PROJECT TITLE: Biosynthesis, Structure, Function, and Regulation of Nitrous Oxide Reductace

INVESTIGATOR: David M. Dooley, Montana State University

FUNDING AGENCY: National Science Foundation

FUNDING AMOUNT: $270,000

DURATION: September 1, 1997 through August 31, 2000

DESCRIPTION: The biochemistry, biosynthesis, structures, reactivity, and function of nitrous oxide reductase, the terminal enzyme in bacterial denitrification, is being investigated. This research project seeks to understand how bacteria in soil and water convert nitrate, an important source of nitrogen for plants, intro nitrogen gas, which is released to the atmosphere. Denitrification may release N20 to the atmosphere, where it may contribute to ozone depletion and global warming.

PROJECT TITLE: Heterogeneity and Scale in Modeling the Economic Impacts of Climate Change in Great Plains Agriculture

INVESTIGATOR/ORGANIZATION: John M. Antle, Department of Agricultural Economics and Economics, Montana State University

FUNDING AGENCY: University of Nebraska, Center for Global Environment

FUNDING AMOUNT: $273,000

DURATION: July 1, 1996 through June 30, 1999

DESCRIPTION: A primary objective of the Great Plains Regional Center is identification and quantification of the hydrological, ecological and human impacts of greenhouse warming in the Great Plains, and ecosystem modeling of processes of net carbon exchanges between terrestrial grassland ecosystems and the atmosphere. The objective of this work is to assess the impacts of spatial and temporal aggregation on regional estimates of the economic impacts of climate change on Great Plains agriculture and link these estimates to the modeling work conducted with the Century model by NREL researchers.

PROJECT TITLE: Water Resources and Global Climate Change: Integrated Assessment of Consequences

INVESTIGATOR/ORGANIZATION: John M. Antle, Department of Agricultural Economics and Economics, Montana State University

FUNDING AGENCY: University of Nebraska, Center for Global Environment

FUNDING AMOUNT: Information requested

DURATION: Information requested

DESCRIPTION: Abstract requested

PROJECT TITLE: Alpine myocota (Agaricales): Rocky Mountain Tundra, U.S.A.

INVESTIGATOR/ORGANIZATION: Cathy Cripps and Egon Horak, Department of Plant Sciences, Montana State University

FUNDING AGENCY: National Science Foundation

FUNDING AMOUNT: $212,449

DURATION: 1999 – three year project

DESCRIPTION: The research is a survey of mushrooms in the Rocky Mountain alpine zones of Montana, Wyoming, and Colorado. The alpine zone is defined as the vegetation zone above treeline (beyond the krummholtz of conifers). It is characterized by low-growing vegetation, persistent winds, cold temperatures, and a short growing season. The largest expanse of tundra in the lower U.S., the Beartooth Plateau, is a floristically diverse alpine region with over 422 species of alpine plants. The tundra biome covers 8 percent of all land, and the alpine tundra deserves to be a high priority of study. Both are being examined for sensitivity to global climate change related to increases in temperature, carbon dioxide, and ultraviolet radiation. Organisms in extreme environments can be indicators of directional climate change. This research will contribute important knowledge of fungi in cold-dominated environments.

PROJECT TITLE: The Effect of Environmental Variability on Grizzly Bear Habitat Use

INVESTIGATOR/ORGANIZATION: Douglas S. Ouren, Montana State University

FUNDING AGENCY: U.S. Geological Survey, Midcontinent Ecological Science Center, Greater Yellowstone Field Station

FUNDING AMOUNT: Information requested

DURATION: Information requested

DESCRIPTION: This project will utilize the pool of knowledge and data collected by the efforts of past Interagency Grizzly Bear Study Team research projects to spatially and temporally synthesize eighteen years of radio telemetry data and compare that to newly collected GPS data in an effort to identify areas of high use at different spatial and temporal scales. In addition to data collected by IGBST, this project will use GIS, radio collars instrumented with GPS and remotely sensed data to further evaluate the extent of annual variation of habitat use areas and compare that with annual variation of environmental variables including climate and fire. Climate change is expected to affect grizzly bears because environmental factors determined by climate affect the physiology, survival, and performance of every wildlife species studies in detail.

(NOTE: The next four projects are being conducted in the McMurdo Dry Valleys of Antarctica. The McMurdo Dry Valleys is not just a unique area, but more importantly, it exists at one end of the arid and cold spectra of terrestrial ecosystems. All ecosystems are dependent upon liquid water and shaped to varying degrees by climate and material transport, but nowhere is this more apparent than in the McMurdo Dry Valleys. In very few places on this planet are there environments where minor changes in climate so dramatically affect the capabilities of organisms to grow and reproduce. The data being collected indicate that the dry valleys are very sensitive to small variations in solar radiation and temperature and that this site may well be an important natural regional-scale laboratory for studying responses to human alterations of climate. While the Antarctic ice sheets respond to climate change on the order of thousands of years, the glaciers, streams, and ice-covered lakes in the McMurdo Dry Valleys respond to change almost immediately. Thus, it is in the McMurdo Dry Valleys that the first effects of climate change in Antarctica should be observed.)

PROJECT TITLE: The Role of Natural Legacy on Ecosystem Structure and Function in a Polar Desert: The McMurdo Dry Valley LTER Program

INVESTIGATOR/ORGANIZATION: John C. Priscu, Department of Biology, Montana State University is one of 8 co-principal investigators on this project.

FUNDING AGENCY: National Science Foundation (continuing grant)

FUNDING AMOUNT: $4,259,979

DURATION: April 1, 1999 through March 31, 2005

DESCRIPTION: The McMurdo Dry Valleys (MCM) region is among the most extreme deserts in the world; far colder and drier than any other Long Term Ecological Research (LTER) site. The biological systems within the MCM are relatively simple with no vascular plants and vertebrates. During MCM-I researchers investigated the perennially ice-covered lakes, ephemeral streams and extensive areas of soils in order to assess the role of physical constraints on the structure and function of the ecosystem. It is clear that the production of liquid water in both terrestrial and aquatic portions of this environment is a primary driver in ecosystem dynamics. Thus, the role of present day climatic variation is extremely important. One of the most significant discoveries of MCM-I was that past climatic legacies strongly overprint the present ecological conditions in MCM. In MCM-II the research will continue to investigate the MCM as an "end-member" system, but also to better ascertain the role of the past climatic legacies on ecosystem structure and function.

PROJECT TITLE: Collaborative Research: The Biogeochemistry of Dimethylsulfied (DMS) and Related Compounds in a Chemically Stratified Antarctic Lake

INVESTIGATOR/ORGANIZATION: John C. Priscu, Department of Biology, Montana State University

FUNDING AGENCY: National Science Foundation

FUNDING AMOUNT: $236,570

DURATION: August 1, 1999 through July 31, 2002

DESCRIPTION: Dimethylsulfide (DMS) is the dominant volatile sulfur compound emitted from the ocean and may represent up to 90 percent of the sea-to-air biogenic sulfur flux. It has been hypothesized that cloud formation caused by condensation nuclei associated with products of DMS oxidation can directly counteract warming effects of anthropogenically produced carbon dioxide. This multi-investigator field and laboratory research will examine the biogeochemistry of water column and sedimentary DMS/DMSP (dimethylsulfoniopropionate), and the role of associated compounds in Lake Bonney. The research will define the sources and sinks of DMS and associated compounds and relate them to overall ecosystem function.

PROJECT TITLE: LEXEN: Collaborative Research: Microbial Life with the Extreme Environment Posed by Permanent Antarctic Lake Ice

INVESTIGATOR/ORGANIZATION: John C. Priscu, Department of Biology, Montana State University, is one of five investigators on this project.

FUNDING AGENCY: National Science Foundation

FUNDING AMOUNT: $488,758

DURATION: August 1, 1998 through July 31, 2001

DESCRIPTION: Three to twenty meter thick permanent ice covers on lakes in the McMurdo Dry Valleys, Antarctica, contain viable microbial cells in association with sediment agregates. These aggregates are now recognized as sites where physical, chemical and biological interactions promote microbial growth under extreme conditions inherent to the ice environment. The work will be on ice aggregates embedded with the permanent ice covers on the lakes in the Taylor Valley. Research on microbes promises to have biotechnological implications.

PROJECT TITLE: Antarctic Lake Ice Microbial Consortia: Origin, Distribution and Growth Physiology

INVESTIGATOR/ORGANIZATION: John C. Priscu, Department of Biology, Montana State University, is one of four investigators on this project.

FUNDING AGENCY: National Science Foundation (continuing grant)

FUNDING AMOUNT: $561,048

DURATION: August 1, 1995 through July 31,1999

DESCRIPTION: The permanent ice cover of Antarctic lakes within the McMurdo Dry Valleys provides a habitat for viable microbial consortia consisting of cyanobacteria and eubacteria. This microbial assemblage, which is concentrated in a liquid water lens associated with a layer of rock debris at mid-ice depth, presumably grows only during a period when the ice cover is not completely frozen. Despite the potential importance this assemblage may have with regard to overall ecosystem dynamics, it has never been studied with respect to its origin, distribution and ecological significance. A majority of this work will focus on the assemblage found in the east lobe of Lake Bonney. This project, which will be the first to examine the Antarctic lake ice microbial assemblage, will yield important new information on carbon and nitrogen dynamics within the McMurdo dry valleys and will complement numerous studies of sea ice microbial communities.

PROJECT TITLE: The Study of Nonlinear Dynamics Leading to Ozone Concentration Oscillations in the Troposphere

INVESTIGATOR/ORGANIZATION: Leonid Kalachev, Department of Mathematics, University of Montana

FUNDING AGENCY: National Aeronautics and Space Administration (regrant through MSU)

FUNDING AMOUNT: $12,000

DURATION: 3/1/1998 through 2/28/1999

DESCRIPTION: In this project analytical and numerical techniques are used to elucidate the basic dynamic structure of the system of equations describing chemical reactions in the troposphere (the portion of the atmosphere which is below the stratosphere, which extends outward about 7 to 10 miles from the earth'' surface, and in which generally temperature decreases rapidly with altitude, clouds form, and convection is active).

PROJECT TITLE: The Role of Ultraviolet Radiation in Maintaining the Three Dimensional Structure of Cyanobacterial Mat Communities and Facilitating and Photosynthesis in These Mats

INVESTIGATOR/ORGANIZATION: Richard P. Sheridan, Division of Biological Sciences, University of Montana

FUNDING AGENCY: National Science Foundation

FUNDING AMOUNT: $57,000

DURATION: August 1, 1997 through July 31, 2000

DESCRIPTION: Communities of cyanobacterial species are important in diverse ecosystems because they have the capacity to convert the inert atmospheric gas nitrogen into ammonia fertilizer. These cyanobacterial communities colonize habitats in which they are exposed to high intensity ultraviolet light, which is increasing in intensity due to depletion of the ultraviolet absorbing ozone layer. Studies proposed include the strategies by which these cyanobacteria adapt to ultraviolet light. The principal investigator has presented the results of preliminary experiments that they employ ultraviolet absorbing pigments which confer protection to cell proteins from UV damage, and that communities of cyanobacteria arrange the component species such that the UV resistant species intercept UV with W sensitive species positioned in strata beneath the upper screening species. When the stressor W is removed, the community becomes disrupted resulting in severe UV damage to the enzymes responsible for nitrogen fixation.

PROJECT TITLE: Climate and Predation Effects on Reproductive Patch Choice and Species Coexistence

INVESTIGATOR/ORGANIZATION: Thomas E. Martin, Montana Cooperative Wildlife Research Unit, University of Montana

FUNDING AGENCY: National Science Foundation

FUNDING AMOUNT: $135,000

DURATION: February 1, 1996 through January 31, 1998

DESCRIPTION: Habitat selection and species coexistence are generally thought to reflect choice of environmental conditions that minimize ecological costs and maximize fitness. Changes in microclimate from weather changes among years should cause dynamic shifts in habitat selection if physiological costs of microclimate are important. Yet, nest site shifts could increase ecological costs if shifts exceed ecological optima. Data collected over the previous six years show that nest sites do shift in response to weather changes. Continued long-term study of this system and nest site shifts is important because such shifts provide an unprecedented opportunity to examine the potential role of biotic versus abiotic influences on habitat selection and species coexistence based on dynamic changes in potential environmental influences.

PROJECT TITLE: Causes and Consequences of Climate Influences on Distribution and Habitat Selection of Migratory Birds

INVESTIGATOR/ORGANIZATION: Thomas E. Martin, Montana Cooperative Wildlife Research Unit, University of Montana

FUNDING AGENCY: U.S. Geological Survey

FUNDING AMOUNT: $382,492 over 4 years (annual funding $95,623)

DURATION: 1/15/99 through 5/14/2003

DESCRIPTION: Management of biological diversity in the face of global climate change requires understanding the interacting effects of climate and vegetation on distribution and coexistence of species. This project will examine the differences in relative sensitivity of the four migratory bird species to changes in climate in terms of: 1) spatial distribution; 2) habitat choice; 3) fecundity; 4) demography; 5) physiological constraints; and 6) biotic consequences. This project will include examination of both local and larger scales and will explore management options needed to minimize negative consequences of climate change.

PROJECT TITLE: Canopy Carbon and Water Fluxes in Terrestrial Ecosystems: Development of an Earth Observing System/Moderate Resolution Image Spectrometer (EOS/MODIS)

INVESTIGATOR/ORGANIZATION: Steven Running, School of Forestry, University of Montana

FUNDING AGENCY: National Aeronautics and Space Administration

FUNDING AMOUNT: $514,000

DURATION: January 7, 1992 through December 31, 1999

DESCRIPTION: The EOS satellite is the flagship of NASA's Earth Science Enterprise. It will be the first EOS platform and will provide global data on the state of the atmosphere, land, and oceans, as well as their interactions with solar radiation and with one another. The launch of the EOS will expand our perspective of the global environment and climate. This project, during the pre-EOS phase, will: 1) develop a means of discriminating different major biome types with Normalized Difference Vegetation Index (NVDI). Project investigators will use field sites from the National Science Foundation Long-Term Ecological Research network, and develop Glacier National Park as a major site for intensive validation. The resulting simple, satellite driven canopy models should allow a vastly improved dynamic computation of surface water and carbon exchange rates by global terrestrial ecosystems and improve accuracy of global carbon and hydrologic budgets.

PROJECT TITLE: International EOS (Earth Observing System) Training Center

INVESTIGATOR/ORGANIZATION: Steven Running, School of Forestry, University of Montana, and George Bailey, EOS Training Project, School of Education, University of Montana

FUNDING AGENCY: National Aeronautics and Space Administration

FUNDING AMOUNT: $1,679,875

DURATION: 12/1/1998 through 2/29/2000

DESCRIPTION: With the anticipated launch of the EOS satellites (see previous project description), the extent and timing of remotely sensed data will reach new levels of regular full earth coverage. Numerous well-studied algorithms will turn the raw information of basic remote sensing into application products covering the globe on a daily to weekly time step. The International EOS Natural Resources Training Center (IENRTC) is a program designed to meet the challenges of educating the public about NASA's newest remote sensing applications. Within the School of Forestry, the Numerical Terradynamic Simulation Group along with the Bolle Center for People and Forests will work to acquire, process, and present EOS data in a relevant and meaningful manner to natural resource managers. In like, the School of Education will plan professional teacher training and teacher inservices to begin to demonstrate the concepts of remote sensing along with basic GIS applications into the classroom environment. Using EOS data products provided by NTSG and supplementing already widely accepted NASA educational programs, the IENRTC will introduce the latest remote sensing concepts to the next generation of users.

PROJECT TITLE: The Impact of Vegetation Changes in the Sahel on Regional Scale Hydrology

INVESTIGATOR/ORGANIZATION: Steven Running, School of Forestry, University of Montana

FUNDING AGENCY: National Aeronautics and Space Administration

DURATION: 7/1/1999 through 6/30/2000

DESCRIPTION: It has long been assumed that widespread "desertification" has altered the landscape of West Africa, with mainly human factors evoking the change. Recently, this conclusion has been challenged by numerous scientists. Now, with almost 20 years of remote sensing data available, scientists have been able to quantify changes in desert extent and biological productivity in the Sahel region. These studies have concluded that in recent years, the primary control on the interannual fluctuations of the "desert" and on the biological productivity of the land has been rainfall variability, more so than human mismanagement of the land. However, the question of longer-term land degradation is still open and requires a careful analysis of the relative controls of climate and human land use on vegetation dynamics. There has been no real assessment of vegetation changes in the region that integrates the changes in climate forcing and human activity with quantified vegetation responses. The goals of this project are to produce such an assessment, to distinguish between human and natural factors in producing the changes, and to assess their hydrologic impact.

PROJECT TITLE: Assessment of Climatic and Anthropogenic Impacts on the Global Carbon Cycle Constrained by Atmospheric Measurements and Remote Sensing Data

INVESTIGATOR/ORGANIZATION: Steven Running, School of Forestry, University of Montana

FUNDING AGENCY: National Aeronautics and Space Administration

FUNDING AMOUNT: $22,127

DURATION: November 1, 1996 through October 31, 1999

DESCRIPTION: The BIOME-BGC (BioGeochemical Cycles) model is a multi-biome generalization of FOREST-BGC, a model originally developed to simulate a forest stand development through a life cycle. The model requires daily climate data and the definition of several key climate, vegetation, and site conditions to estimate fluxes of carbon, nitrogen, and water through ecosytems. This project will work on model development and testing, and will implement new vegetation maps, adapting vegetation types to the seven biome types used the BIOME-BGC. It will also perform decade-long simulations for the BGC model.

PROJECT TITLE: Developing a Global Phenology Monitor: A Method for Detecting Biospheric Responses to Climate Change

INVESTIGATOR/ORGANIZATION: Steven Running, School of Forestry, University of Montana

FUNDING AGENCY: National Aeronautics and Space Administration

FUNDING AMOUNT: $22,000

DURATION: September 1, 1996 through August 31, 1999

DESCRIPTION: A global phenology monitor will be developed to measure short and long-term vegetation response to climate change. The phenology of all vegetation is intimately connected with day-to-day variation in meteorology, which is in turn ultimately determined by macroscale climatic influences. If Global Circulation Model predictions for a warmer, drier climate are fulfilled, it is likely that the dynamics of vegetation phenology will be commensurately altered. Phenological change detection through remote sensing is a promising method of monitoring the direct impact of climate change on the terrestrial biosphere. The research will develop and test an automated, satellite-based phenology monitor in four phases of research. The primary scientific benefits of the monitor will be 1) a long-term monitor of biosphere responses to climate change and 2) a tool which may be used by ecosystem modelers to check and/or calibrate their phenological equations.

PROJECT TITLE: Assimilation of Remotely Sensed Parameter Maps into BIOME-BMC Process Model over BOREAS Study Area

INVESTIGATOR/ORGANIZATION: Steven Running and John Kimball, School of Forestry, University of Montana

FUNDING AGENCY: National Aeronautics and Space Administration

FUNDING AMOUNT: $66,586

DURATION: June 1, 1997 through May 31, 2000

DESCRIPTION: Integration of the BIOME-BGC (BioGeochemical Cycles) process model derived from remote sensing data over BOREAS (boreal ecosystem atmosphere study) sites offers the best framework to achieve the following objectives: 1) to extrapolate stand level hydrologic and carbon exchange processes to regional scales; 2) to examine the effect of special variability of input parameters on surface flux estimates; and 3) to establish documented levels of accuracy for regional hydrologic and carbon balance estimates and the relevant input parameters. The overall goal of BOREAS is to improve our understanding of the interactions between the boreal forest biome and the atmosphere, clarifying their roles in global change. BIOME-BGC is a process level ecosystem simulation model that describes the cycling of water, carbon, and nitrogen through forest ecosystems.

PROJECT TITLE: Proof of Concept of Radar-based Measure of Interannual Vegetation Phenology for Monitoring Global Change Responses of Vegetation

INVESTIGATOR/ORGANIZATION: Steven Running, School of Forestry, University of Montana

FUNDING AGENCY: National Aeronautics and Space Administration

FUNDING AMOUNT: $134,043

DURATION: September 1, 1997 through August 31, 1999

DESCRIPTION: Abstract requested.

PROJECT TITLE: VEMAP Phase II: Model Intercomparison of Primary Production Maps of the Continental United States

INVESTIGATOR/ORGANIZATION: Steven Running, School of Forestry, University of Montana

FUNDING AGENCY: National Aeronautics and Space Administration

FUNDING AMOUNT: $169,800

DURATION: November 1, 1997 through October 31, 1999

DESCRIPTION: The Vegetation/Ecosystem Modeling and Analysis Project (VEMAP) is an ongoing multi-institutional, international effort addressing the response of biogeography and biogeochemistry to environmental variability in climate and other drivers in both space and time domains. The objectives of VEMAP are the intercomparison of biogeochemistry models and vegetation-type distribution models and determination of their sensitivity to changing climate, elevated atmospheric carbon dioxide concentrations, and other sources of altered forcing. The completed Phase 1 of the project was structured as a sensitivity analysis, with factorial combinations of climate (current and projected under doubled carbon dioxide), atmospheric carbon dioxide, and mapped and model-generated vegetation distributions. VEMAP is currently in the second phase of model intercomparison and analysis. The objectives of Phase 2 are to compare time-dependant ecological responses of biogeochemical and coupled biogeochemical-biogeographical models to historical and projected transient forcings across the conterminous U.S. These model experiments will be driven by historical time series and projected transient scenarios of climate, atmospheric carbon dioxide, and N-deposition.

PROJECT TITLE: Global Change Research Program, Glacier National Park

INVESTIGATOR/ORGANIZATION: Daniel B. Fagre, Global Change Research Coordinator, Glacier Field Station, USGS-Biological Resources Division

FUNDING AGENCY: U.S. Geological Survey in partnership with the National Park Service

DURATION: 1991 to present

DESCRIPTION: As numerous new studies and ongoing monitoring efforts affirm that major climatic changes are occurring, there is even greater urgency to understand how such changes are, and will be, affecting our natural resources. Large national parks, such as Glacier, are uniquely suited to play a pivotal role in understanding climate change from two perspectives: 1) Glacier National Park is at the heart of a relatively unaltered ecosystem. Only in such places can we separate the relative role of climate from human activities in shaping ecosystem dynamics and the landscapes we see; and 2) Monitoring climate and ecosystem health parameters in national parks provide benchmarks against which global changes can be measured because the confounding influence of humans has been minimized.

The Global Change Research Program at Glacier National Park is built around developing the understanding and the techniques to provide quantitative, spatially-explicit estimates of ecosystem processes (e.g., rates of photosynthesis) and translate these into landscapes that can be viewed on a Geographic Information System. The Global Change Research Program is a suite of interrelated basic research and monitoring projects that collectively assess probable impacts of climate change on park resources. Through collaboration with universities and other federal agencies, global change projects include: 1) forest ecosystem modeling; 2) hydrological studies; 3) aquatic biota inventories; 4) monitoring of glacial movements; and 5) simulation of regional fire probabilities.

NOTE: Many of the Global Change Research Program monitoring and research projects are listed in the following pages.

PROJECT TITLE: Ecosystem Responses to Global Change in the Northern Rocky Mountains (This is the principal project of the Global Change Research Program at Glacier National Park. It encompasses many of the projects listed below)

INVESTIGATOR/ORGANIZATION: Daniel B. Fagre, USGS-BRD Glacier Field Station, Glacier National Park, and co-investigators Steven Running, School of Forestry, University of Montana, and F. Richard Hauer, Flathead Lake Biological Station, University of Montana

FUNDING AGENCY: U.S. Geological Survey (Global Change Research Program at Glacier National Park)

FUNDING AMOUNT: $20,238,000 for seven year period starting in 1991. (Much of this funding covers the projects listed as part of the Global Change Research Program at Glacier National Park.)

DURATION: 1991 to present

DESCRIPTION: The objective is to assess the probable impacts of global changes on the natural resources of a mountain protected area and to provide managers with a basis for making decisions about the future. Secondary objectives include the development of a comprehensive ecosystem model and a long-term monitoring program to detect ecological changes. The ecosystem dynamics of Glacier National Park has been examined for six years using modeling and extensive field investigations to estimate impacts of climate change and other stressors. The Regional Hydro-ecological Simulation System was developed to predict carbon budgets, hydrologic discharge, and other processes for two topographically diverse mountain watersheds. A network of remote automated weather stations, snow transects, stream gauges, soil carbon plots and other sampling locations was operated over five years for validation and continued through 1997. Project investigators are currently developing the capability to simulate future wild life habitats to predict climate change impacts for species of concern.

PROJECT TITLE: Modeling and Analysis of Forest Landscape Dynamics in Relation to Climate Change (see related project "Development and Implementation of the Regional Hydro-Ecological Simulation System (RHESSys) Model at the Lake McDonald Watershed")

INVESTIGATOR/ORGANIZATION: Kevin Ryan and Robert Keane, USDA Forest Service, Intermountain Fire Sciences Laboratory, Missoula, Steven Running and Joseph White, School of Forestry, University of Montana, and Dan Fagre and Carl Key, U.S.G.S. Glacier Field Station, Glacier National Park

FUNDING AGENCY: U. S. Geological Survey (Global Change Research Program at Glacier National Park)

FUNDING AMOUNT:

DURATION: 1995(?) to present

DESCRIPTION: A dynamic, spatially explicit Regional Ecosystem Simulation System (RESSys), will be implemented for the Glacier National Park Area as a vehicle to study potential effects of global climatic change on natural ecosystems of the park. RESSys integrates satellite definition of biome type, land cover and leaf area index with topographic and soils data, calculates a drainage network, a daily microclimate map, then simulates hydrologic, carbon and nitrogen balances of the landscape. With RESSys, the results of the climate change projections for Glacier National Park will be mapped three-dimensionally for a variety of hydrologic, carbon cycle and forest community variables. Snow surveys in the Lake McDonald Basin are continuing and seven automated climate stations have been established at the upper elevations of the Lake McDonald and St. Mary basins and have been operating for several years.

PROJECT TITLE: Development and Implementation of the Regional Hydro-Ecological Simulation System (RHESSys Model at the Lake McDonald Watershed (See related project, "Modeling and Analysis of Forest Landscape Dynamics in Relation to Climate Change)

INVESTIGATOR/ORGANIZATION: Steven Running and Joseph White, School of Forestry, University of Montana, and Kevin Ryan and Robert Keane, USDA Forest Service, Intermountain Fire Sciences Laboratory, Missoula

FUNDING AGENCY: U.S. Geological Survey (Global Change Research Program at Glacier National Park)

FUNDING AMOUNT:

DURATION: 1995(?) to present

DESCRIPTION: Understanding the responses of ecosystems to climate change requires better understanding of ecosystem structure and functions. The Regional Hydro-Ecological Simulation System incorporates remote sensing information, GIS technology and biophysical modeling to provide spatially-explicit estimates of ecosystem processes such as net primary production or snow water equivalent. One recent activity was the successful linking of the FIRESUM individual tree gap-phase model with the mechanistic ecophysiological FOREST-BGC model. This "hybrid" model, now called FIREBGC provides age- and species-specific forest stand characteristics which can be mapped for specific areas, such as the Lake McDonald drainage. With this capability integrated into RHESSys, park managers can "view" future distributions of forest types when mapped by a GIS under different scenarios of change. These changes could be climate-driven or external influences resulting from altered land use patterns. To simulate the effects of stand age development and fuel loading on future forest fire potential, the model FARSITE was developed. FARSITE will be used in global change scenarios to account for the increasing role which stand-replacement fires will have on the regional landscape as conditions become drier. Landscape disturbances of such a magnitude may become the dominant force shaping future ecosystem dynamics.

PROJECT TITLE: Glacier Monitoring in Glacier National Park

INVESTIGATOR/ORGANIZATION: Daniel B. Fagre and Carl H. Key, USGS-Biological Resources Division, Glacier Field Station, Glacier National Park

FUNDING AGENCY: U.S. Geological Survey (Global Change Research Program at Glacier National Park)

FUNDING AMOUNT:

DURATION: Ongoing

DESCRIPTION: Glacial fluctuations in Glacier National Park have been studied, with published reports dating back to 1914. From these studies, the glaciers of Glacier National Park appear to be excellent barometers of climate change. Long-term reductions in glacier size reflect long-term increases in average temperature and/or reductions in winter snow. An increase of approximately 1 degree centigrade in average summer temperatures is reflected in reduced glacier sizes. A computer model indicates that present rates of increasing warming will eliminate all glaciers in Glacier National Park by 2030. Even with no additional warming over that which has already occurred in the Glacier Park area, the glaciers are likely to be gone by 2100.

PROJECT TITLE: Ultraviolet (UV) Radiation Monitoring in Glacier National Park

INVESTIGATOR/ORGANIZATION: Cooperative effort of the National Park Service and the U.S. Geological Survey

FUNDING AGENCY: U.S. National Park Service, U.S. Geological Survey, U.S. Environmental Protection Agency

FUNDING AMOUNT:

DURATION: 1996 to present

DESCRIPTION: Glacier National Park belongs to a network of parks that have similar UV monitoring programs. This network, called Park Research and Intensive Monitoring of Ecosystems Network (PRIME-Net), was established in 1996 as a joint effort between the U.S. Environmental protection Agency and the National Park Service to document changes in land and water surface UV exposure and to document the ecological and human health related effects of these changes. In Glacier, research efforts are focusing on UV-B radiation. Work is being done to assess the effect of UV-B on amphibian populations in the park. Understanding the effects of UV radiation at this local scale is the first step in understanding its global effects. Also, data from Glacier and the other PRIME-Net sites will help scientists monitor UV-B levels globally to determine if international efforts to phase out ozone-depleting substances have been successful in reversing the thinning of the ozone layer.

PROJECT TITLE: Effects of Climate Change on Hydrologic Systems and Associated Biota

INVESTIGATOR/ORGANIZATION: F. Richard Hauer, Jack Stanford, Flathead Lake Biological Station, University of Montana.

FUNDING AGENCY: U.S. Geological Survey (Global Change Research Program at Glacier National Park)

FUNDING AMOUNT: $72,000

DURATION: June 30, 1998 through June 29, 2000 (continuing project)

DESCRIPTION: Climate changes on the planet during the next century are expected to have major impacts on region freshwater ecosystems. Although the task of predicting future climate scenarios and resulting biological consequences is daunting, there is general agreement that aquatic systems will likely undergo alterations in water quantity, water quality and thermal dynamics. Small shifts in any of these attributes could substantially alter the diverse and typically fragile biota occupying freshwater habitats in pristine areas like Glacier National Park. The purpose of this study is to address some of the questions relevant to understanding and predicting the effects of climate change on hydrologic processes and resulting impacts on water ecosystems.

ATTACHMENT 3:

INCENTIVES FOR ALTERNATIVE ENERGY AND ENERGY EFFICIENCY

August 19, 1999

AGRICULTURE

90-2-140. Energy conservation in agriculture. (1) The department of environmental quality is authorized to make grants under its state energy conservation program, approved pursuant to 10 CFR 420.5, to conservation districts for projects that promote energy conservation in agriculture.

(2) The department of environmental quality shall give public notice of opportunity for grants and the criteria to be used for the award of grants. The criteria must include but are not limited to energy savings and consistency with sound water and soil conservation practices.

History: En. Sec. 6, HB 621, L. 1987; amd. Sec. 489, Ch. 418, L. 1995.

(Note: These grants were funded through oil overcharge monies while funding was available – the grant program is no longer active.)

ALTERNATIVE FUELS AND FUEL BLENDS

(e.g., gasohol, natural gas, lpg, lng, hydrogen, electricity)

15-6-135. Class five property -- description -- taxable percentage. (1) Class five property includes:

(a) all property used and owned by cooperative rural electrical and cooperative rural telephone associations organized under the laws of Montana, except property owned by cooperative organizations described in 15-6-137(1)(b);

(b) air and water pollution control equipment as defined in this section;

(c) new industrial property as defined in this section;

(d) any personal or real property used primarily in the production of gasohol during construction and for the first 3 years of its operation;

(e) all land and improvements and all personal property owned by a research and development firm, provided that the property is actively devoted to research and development.

15-6-135(5) Class five property is taxed at 3% of its market value.

15-30-164. Credit for alternative fuel motor vehicle conversion. (1) (a) Except as provided in subsection (1)(b), an individual, a corporation, a partnership, or a small business corporation as defined in 15-31-201 is allowed a tax credit against taxes imposed by 15-30-103 or 15-31-101 for equipment and labor costs incurred to convert a motor vehicle licensed in Montana to operate on alternative fuel.

(b) A seller of alternative fuel may not receive a credit for converting its own vehicles to the alternative fuel that it sells.

(2) The maximum credit a taxpayer may claim in a year under this section is an amount equal to 50% of the equipment and labor costs incurred but the credit may not exceed:

(a) \$500 for conversion of a motor vehicle with a gross weight of 10,000 pounds or less; or

(b) \$1,000 for conversion of a motor vehicle with a gross vehicle weight over 10,000 pounds.

(3) For the purposes of this section, "alternative fuel" means:

(a) natural gas;

(b) liquefied petroleum gas;

(c) liquefied natural gas;

(d) hydrogen;

(e) electricity; or

(f) any other fuel if at least 85% of the fuel is methanol, ethanol or other alcohol, ether, or any combination of them.

(4) (a) The credit allowed under this section may not exceed the taxpayer's income tax liability.

(b) There is no carryback or carryforward of the credit permitted under this section, and the credit must be applied in the year the conversion is made, as determined by the taxpayer's accounting method.

History: En. Sec. 1, Ch. 617, L. 1993.

15-70-522. Tax incentive for production of alcohol -- written plan required -- reservation of incentives -- rules. (1) (a) If the alcohol was produced in Montana from Montana agricultural products, including Montana wood or wood products, or if the alcohol was produced from non-Montana agricultural products when Montana products are not available, there is a tax incentive payable to alcohol distributors for distilling alcohol that:

(i) was blended with gasoline for sale as gasohol in Montana;

(ii) was exported from Montana and has been blended with gasoline for sale as gasohol; or

(iii) was used in the production of ethyl butyl ether for use in reformulated gasoline.

(b) Payment must be made by the department out of the amount collected under 15-70-204.

(2) Except as provided in subsections (3) and (4), the tax incentive on each gallon of alcohol distilled in accordance with subsection (1) is 30 cents per gallon for each gallon that is

100% produced from Montana products, with the amount of the tax incentive per gallon reduced proportionately, based upon the amount of agricultural or wood products not produced in Montana that is used in the production of the alcohol, and beginning July 1, 2005, there is no tax incentive.

(3) Regardless of the alcohol tax incentive provided in subsection (2), the total payments made for the incentive under this part may not exceed $6 million in any consecutive 12-month period.

(4) An alcohol distributor may not receive tax incentive payments under subsection (2) that exceed $3 million in any consecutive 12-month period.

(5) An alcohol distributor who begins production after July 1, 1991, may not receive tax incentive payments under subsection (2) unless the distributor has provided a written plan to the department of transportation at least 18 months before the distributor's anticipated collection of the tax incentives. The plan must contain the following information:

(a) the source or sources of financing for the acquisition of the plant, land, and equipment used for the production of gasohol;

(b) the anticipated source of agricultural products used in the production of gasohol; and

(c) the anticipated time, quantity, and duration of production of gasohol.

(6) An alcohol distributor in production before July 1, 1991, is entitled to apply for the maximum tax incentive payment allowed under subsection (4) without providing a written plan as required in subsection (5).

(7) (a) Except as provided in subsection (7)(b), the department shall reserve, in the order that written plans required under subsection (5) are received by the department, alcohol tax incentives based on the anticipated time, quantity, and duration of production. Payment of the alcohol tax incentives must be based on actual production.

(b) No later than 1 year after the written plan is received under subsection (5), the department shall determine whether an alcohol distributor is complying with the written plan. The department may reduce or cancel the reservation of the tax incentive provided in this subsection (7) if the department determines that the alcohol distributor has not materially complied with the written plan.

(8) A new tax incentive payment may not be made if the total tax incentive established in subsection (3) has been reserved or paid. If an alcohol tax incentive has been reduced or canceled, the amount by which the tax incentive has been reduced or canceled is available for reservation as provided in subsection (7)(a).

(9) The department shall prescribe rules necessary to carry out the provisions of this section.

History: En. Sec. 9, Ch. 649, L. 1983; amd. Sec. 3, Ch. 697, L. 1985; amd. Sec. 1, Ch. 593, L. 1989; amd. Sec. 8, Ch. 512, L. 1991; amd. Sec. 2, Ch. 723, L. 1991; amd. Sec. 1, Ch. 592, L. 1993; amd. Sec. 1, Ch. 510, L. 1997.

90-4-1011. Alternative fuels policy -- implementing guidelines. (1) The state of Montana encourages the use of alternative fuels and fuel blends to the extent that doing so produces environmental and economic benefits to the citizens of Montana.

(2) To implement the policy stated in subsection (1), the legislature recommends the following guidelines:

(a) All policies and programs should have in-state benefits.

(b) Policies and programs should be coordinated among the affected agencies.

(c) The state recognizes incentives as a temporary tool to implement the alternative fuels policy. Recipients of those incentives should develop a plan, including an educational component, to phase out the incentive. In determining incentives, the state should:

(i) consider incentives for the producer, retail, and consumer levels;

(ii) establish a logical link between revenue sources and incentives; and

(iii) encourage the use of self-sufficient markets.

(d) Any state alternative fuels program should have measurable benefits that are communicated to the public.

(e) State and local governments should be encouraged to set an example with their vehicle fleets in the use of alternative fuels and fuel blends.

(f) Consistent with the guidelines in subsections (2)(a) through (2)(e), the state encourages production of alternative fuels and fuel blends.

History: En. Sec. 3, Ch. 311, L. 1995.

BUILDINGS ENERGY CONSERVATION

15-32-103. Deduction for energy-conserving investments. (1) In addition to all other deductions from gross corporate income allowed in computing net income under chapter 31, part 1, a taxpayer may deduct a portion of his expenditure for a capital investment in a building for an energy conservation purpose, in accordance with the following schedule:

If the installation or investment is made in a residential building:	If the installation or investment is made in a building not used as a residence
100% of first $1,000 expended	100% of first $2,000 expended
50% of next $1,000 expended	50% of next $2,000 expended
20% of next $1,000 expended	20% of next $2,000 expended
10% of next $1,000 expended	10% of next $2,000 expended

15-32-105. Application to new construction -- rules. (1) It is the intent of the legislature that no deduction or credit under this part be allowed for capital investment for an energy conservation practice in the new construction of a building if that capital investment would have been made under established standards of new construction. The department of revenue shall adopt rules to implement this legislative intent. Such rules shall be based on the best currently available methods of analysis, including those of the national bureau of standards, the department of housing and urban development, and other federal agencies and professional societies and materials developed by the department. Provisions shall be made for an annual updating of rules and standards as required.

(2) The department may adopt rules to define standard components of conventional buildings and to establish other necessary elements of the definition of passive solar system consistent with the intent of 15-32-102.

History: En. Sec. 6, Ch. 576, L. 1977; amd. Sec. 7, Ch. 480, L. 1981.

15-32-109. Credit for energy-conserving expenditures. (1) Subject to the restrictions of subsections (2) and (3), a resident individual taxpayer may take as a credit against the taxpayer's tax liability under chapter 30 a portion of his expenditure for a capital investment in a building for an energy conservation purpose, determined as follows:

(a) in the case of an expenditure for a residential building, the lesser of:

(i) $150; or

(ii) 5% of the expenditure; and

(b) in the case of an expenditure for a building not used as a residence, the lesser of:

(i) $300; or

(ii) 5% of the expenditure.

(2) The credit or the sum of the credits under subsection (1):

(a) may not exceed the taxpayer's tax liability; and

(b) is subject to the provisions of 15-32-104.

(3) There is no carryback or carry-forward of the credit permitted under this section, and the credit must be applied in the year the expenditure is incurred, as determined by the taxpayer's accounting method.

History: En. Sec. 1, Ch. 480, L. 1981.

90-2-141. State-owned building retrofitting. (1) The department of environmental quality is authorized, in consultation with the department of administration, to train employees in the operation and maintenance of energy saving equipment and in the implementation of energy conserving practices and to make grants to state agencies for energy efficiency analysis of state-owned buildings. The department of environmental quality may also make loans to state agencies for retrofitting state-owned buildings.

(2) The department of environmental quality shall consider simple payback, type of energy saved, results of similar projects, expected life of the retrofit, and use of the retrofit as a model for other buildings in making grants and loans under subsection (1).

History: En. Sec. 7, HB 621, L. 1987; amd. Sec. 490, Ch. 418, L. 1995

90-4-611. Authority to issue energy conservation program bonds. (1) When authorized by the vote of two-thirds of the members of each house of the legislature, at the request of the department, and pursuant to this part, the board may issue and sell bonds or bond anticipation notes of the state in a manner it considers necessary and proper to finance the energy conservation program and to pay costs associated with the sale and issuance of the bonds. Bonds may be issued to provide funds for the payment or redemption of energy conservation building program bonds issued under this section.

(2)The full faith and credit and taxing powers of the state are pledged for the prompt and full payment of all bonds so issued and interest and redemption premiums payable on the bonds according to their terms.

History: En. Sec. 6, Ch. 473, L. 1989.

GEOTHERMAL SYSTEMS

15-32-115. Credit for geothermal system -- to whom available -- eligible costs -- limitations.

(1) A resident individual taxpayer who completes installation of a geothermal system, as defined in 15-32-102, in the taxpayer's principal dwelling is entitled to claim a tax credit, as provided in subsection (3), against the taxpayer's tax liability under chapter 30 for a portion of the installation costs of the system, up to $250 per year for 4 years. The credit may not exceed the taxpayer's income tax liability for the taxable year in which the credit is claimed.

(2) For the purposes of this section, installation costs include the cost of:

(a) trenching, well drilling, casing, and downhole heat exchangers;

(b) piping, control devices, and pumps that move heat from the earth to heat or cool the building;

(c) ground source or ground coupled heat pumps;

(d) liquid-to-air heat exchanger, ductwork, and fans installed with a ground heat well that pump heat from a well into a building; and

(e) design and labor.

(3) The tax credit allowed under this section is deductible from the taxpayer's income tax liability for the taxable year in which the installation costs were incurred and for the next 3 taxable years succeeding the taxable year in which the installation costs were incurred. There is no carryback or carryforward of the credit permitted under this section.

History: En. Sec. 2, Ch. 646, L. 1991.

NONFOSSIL FORM OF ENERGY GENERATION OR LOW-EMISSION WOOD OR BIOMASS COMBUSTORS

15-6-201(3) The following portions of the appraised value of a capital investment in a recognized nonfossil form of energy generation or low emission wood or biomass combustion devices, as defined in 15-32-102, are exempt from taxation for a period of 10 years following installation of the property:

(a) $20,000 in the case of a single-family residential dwelling;

(b) $100,000 in the case of a multifamily residential dwelling or a nonresidential structure."

15-32-201. Amount of credit -- to whom available. (1) A resident individual taxpayer who completes installation of an energy system using a recognized nonfossil form of energy generation, as defined in 15-32-102, in the taxpayer's principal dwelling prior to January 1, 1993, or who acquires title to a dwelling prior to January 1, 1993, that is to be used as the taxpayer's principal dwelling and is equipped with an energy system for which the credit allowed by this part has never been claimed is entitled to claim a tax credit in an amount equal to 10% of the first $1,000 and 5% of the next $3,000 of the cost of the system, including installation costs, less grants received or, if the federal government provides for a tax credit substantially similar in kind (not in amount), then a tax credit in an amount equal to 5% of the first $1,000 and 2 1/2% of the next $3,000 of the cost of the system, including installation costs, less grants received, against the income tax liability imposed against the taxpayer pursuant to chapter 30.

(2) A resident individual taxpayer who completes installation of an energy system using a low emission wood or biomass combustion device, as defined in 15-32-102(5)(a), in the taxpayer's principal dwelling prior to January 1, 1996, is entitled to claim a tax credit in an amount equal to 20% of the first $1,000 and 10% of the next $3,000 of the cost of the system, including the installation costs, against the income tax liability imposed against the taxpayer pursuant to Title 15, chapter 30.

(3) A resident individual taxpayer who completes installation of an energy system that uses a low emission wood or biomass combustion device, as defined in 15-32-102(5)(b), in the taxpayer's principal dwelling prior to January 1, 1996, is entitled to claim a tax credit in an amount equal to 10% of the first $1,000 and 5% of the next $3,000 of the cost of the system, including the installation costs, against the income tax liability imposed against the taxpayer pursuant to Title 15, chapter 30.

History: En. 84-7414 by Sec. 1, Ch. 574, L. 1977; R.C.M. 1947, 84-7414(1); amd. Sec. 1, Ch. 480, L. 1983; amd. Sec. 2, Ch. 513, L. 1985; amd. Sec. 3, Ch. 467, L. 1991; amd. Sec. 27, Ch. 10, L. 1993; amd. Sec. 75, Ch. 42, L. 1997.

RECLAIMABLE MATERIAL AND RECYCLED PRODUCTS

(See Solid Waste Management)

RESEARCH, DEVELOPMENT, DEMONSTRATION

(Sections 90-4-103 and 109 listed below were amended by the1999 Legislature; the changes are reflected in the following text. Although these programs are still on the books, they are no longer active.)

90-4-103. Alternative energy and energy conservation research development and demonstration program -- allocation of funds. (1) There is an alternative energy and energy conservation research development and demonstration program. Money from repayments of grants and loans previously awarded must be deposited in the general fund.. The state treasurer shall draw warrants payable from appropriations provided for the program upon order of the department.

(2) Each fiscal year the department shall allocate the funds appropriated for the alternative energy and energy conservation research development and demonstration program for the following:

(a) grants under 90-4-104 and 90-4-106;

(b) loans under 90-4-104 and 90-4-106;

(c) grants to state governmental units under 90-4-109;

(d) program administration; and

(e) matching federal energy programs and petroleum violation escrow account money if consistent with the purposes of this chapter.

(3) To ensure that the program offers the greatest possible benefits during the fiscal year, the department may reallocate funds among the categories specified in this section based on the availability of funds or the applications it receives and the department's evaluation of the relative merits of each project.

History: (1)En. 84-7409 by Sec. 3, Ch. 501, L. 1975; R.C.M. 1947, 84-7409; amd. Sec. 3, Ch. 98, L. 1983; amd. Sec. 1, Ch. 277, L. 1983; (2), (3)En. Sec. 4, Ch. 8, Sp. L. June 1986; amd. Secs. 2, 7, Ch. 626, L. 1989; amd. Sec. 492, Ch. 418, L. 1995; amd. Section 90.4-103, Ch. 398, L. 1999.

90-4-105. Applications for grants or loans. Any person may apply for a grant to enable him to research, develop, or demonstrate energy conservation or alternative renewable energy sources. Any person may apply for a loan to commercialize alternative renewable energy sources. The department shall prescribe the form for applications. Applicants shall describe the nature of their proposed investigations, including practical applications of the possible results and time requirements.

History: En. 84-7411 by Sec. 6, Ch. 501, L. 1975; R.C.M. 1947, 84-7411; amd. Sec. 3, Ch. 356, L. 1981; amd. Sec. 5, Ch. 98, L. 1983.

90-4-109. State governmental unit grants. (1) (a) The department may award grants from the alternative energy and energy conservation research development and demonstration appropriations to state governmental units. These grants must be used to further the purposes of this part by providing money for state governmental units for energy conservation measures.

(b) State governmental units shall apply to the department for grants.

(c) The department shall prescribe the form for applications and develop criteria for awarding grants under this section, including provisions requiring matching funds or repayment of grant funds to the general fund.

(d) Each agency awarded a grant shall either repay the grant or reduce its budget commensurate with the documented energy savings resulting from the grant.

(2) All grants awarded under this section must be administered by the department of administration according to Title 18, chapter 2.

History: En. Sec. 4, Ch. 730, L. 1985; amd. Sec. 2, Ch. 8, Sp. L. June 1986; amd. Sec. 90-4-109, Ch. 398, L. 1999.

90-4-215. Account established -- use. (1) There is created an energy conservation and energy assistance account within the federal special revenue fund established in 17-2-102.

(2) The amounts deposited in the account and interest and earnings on the account may be used by the department of public health and human services to fund its low-income energy assistance and home weatherization programs created in 90-4-201. However, the department may use the principal of the account only if the federal grants for either of those programs are reduced below the federal fiscal year 1987 level. The department may not use the principal to increase expenditures to either program above the level of the federal grant for that program for federal fiscal year 1987.

History: En. Sec. 3, HB 621, L. 1987; amd. Sec. 564, Ch. 546, L. 1995; amd. Sec. 90-4-215, Ch. 398, L. 1999.

SOLAR AND WIND ENERGY

15-32-402. Commercial investment credit -- wind-generated electricity. (1) An individual, corporation, partnership, or small business corporation as defined in 15-31-201 that makes an investment of $5,000 or more in certain depreciable property qualifying under section 38 of the Internal Revenue Code of 1954, as amended, for a commercial system located in Montana which generates electricity by means of wind power is entitled to a tax credit against taxes imposed by 15-30-103 or 15-31-121 in an amount equal to 35% of the eligible costs, to be taken as a credit only against taxes due as a consequence of taxable or net income produced by one of the following:

(a) manufacturing plants located in Montana that produce wind energy generating equipment;

(b) a new business facility or the expanded portion of an existing business facility for which the wind energy generating equipment supplies, on a direct contract sales basis, the basic energy needed; or

(c) the wind energy generating equipment in which the investment for which a credit is being claimed was made.

(2) For purposes of determining the amount of the tax credit that may be claimed under subsection (1), eligible costs include only those expenditures that qualify under section 38 of the Internal Revenue Code of 1954, as amended, and that are associated with the purchase, installation, or upgrading of:

(a) generating equipment;

(b) safety devices and storage components;

(c) transmission lines necessary to connect with existing transmission facilities; and

(d) transmission lines necessary to connect directly to the purchaser of the electricity when no other transmission facilities are available.

(3) Eligible costs under subsection (2) must be reduced by the amount of any grants provided by the state or federal government for the system.

History: En. Sec. 2, Ch. 648, L. 1983.

70-17-101(19). Servitudes attached to land. The following land burdens or servitudes upon land may be attached to other land as incidents or appurtenances and are then called easements: (19) the right of receiving sunlight or wind for recognized nonfossil forms of energy generation;

History: En. Sec. 1250, Civ. C. 1895; re-en. Sec. 4507, Rev. C. 1907; re-en. Sec. 6749, R.C.M. 1921; Cal. Civ. C. Sec. 801; Field Civ. C. Sec. 245; re-en. Sec. 6749, R.C.M. 1935; amd. Sec. 16, Ch. 489, L. 1975; R.C.M. 1947, 67-601; amd. Sec. 1, Ch. 209, L. 1983; amd. Sec. 1, Ch. 111, L. 1993.

70-17-301. Creation of solar easements. An easement obtained for the purpose of exposure of a solar energy device must be created in writing and is subject to the same conveyancing and instrument recording requirements as other easements on real property.

History: En. Sec. 1, Ch. 524, L. 1979.

70-17-302. Content of solar easements. An instrument creating a solar easement must specify at least:

(1) and the vertical horizontal angles, expressed in degrees, at which the solar easement extends over the real property subject to the solar easement; and

(2) any terms or conditions under which the solar easement is granted or will be terminated.

History: En. Sec 2, Ch. 524, L. 1979.

70-17-303. Wind energy easement. (1) An easement obtained for the purpose of insuring the undisturbed flow of wind across the real property of another must be created in writing and is subject to the same conveyancing and instrument recording requirements as other easements on real property.

(2) An instrument creating a wind energy easement must include:

(a) a legal description of the real property benefited and burdened by the easement;

(b) a description of the dimensions of the easement sufficient to determine the horizontal space across and the vertical space above the burdened property that must remain unobstructed;

(c) the restrictions placed upon vegetation, structures, and other objects that would impair or obstruct the windflow across and through the easement; and

(c) the terms or conditions, if any, under which the easement may be changed or terminated.

History: En. Sec. 2, Ch. 209, L. 1983.

SOLID WASTE MANAGEMENT

(reclaim, recycle)

15-32-602. (Temporary) Amount and duration of credit -- how claimed. (1) An individual, corporation, partnership, or small business corporation, as defined in 15-31-201, may receive a credit against taxes imposed by Title 15, chapter 30 or 31, for investments in depreciable property to collect or process reclaimable material or to manufacture a product from reclaimed material, if the taxpayer qualifies under 15-32-603.

(2) Subject to 15-32-603(3) and subsection (4) of this section, a taxpayer qualifying for a credit under 15-32-603 is entitled to claim a credit, as provided in subsection (3) of this section, for the cost of each item of property purchased to collect or process reclaimable material or to manufacture a product from reclaimed material only in the year in which the property was purchased. If qualifying property was purchased prior to January 1, 1992, but on or after January 1, 1990, a taxpayer is entitled to a credit for tax year 1992.

(3) The amount of the credit that may be claimed under this section for investments in depreciable property is determined according to the following schedule:

(a) 25% of the cost of the property on the first $250,000 invested;

(b) 15% of the cost of the property on the next $250,000 invested; and

(c) 5% of the cost of the property on the next $500,000 invested.

(4) A credit may not be claimed for investments in depreciable property in excess of $1 million. (Terminates December 31, 2001--sec. 1, Ch. 411, L. 1997.)

History: En. Sec. 2, Ch. 712, L. 1991; amd. Sec. 2, Ch. 542, L. 1995.

15-32-610. (Temporary) Deduction for purchase of recycled material. In addition to all other deductions from adjusted gross individual income allowed in computing taxable income under Title 15, chapter 30, or from gross corporate income allowed in computing net income under Title 15, chapter 31, part 1, a taxpayer may deduct an additional amount equal to 10% of the taxpayer's expenditures for the purchase of recycled material that was otherwise deductible by the taxpayer as business-related expense in Montana. (Terminates December 31, 2001--sec. 4, Ch. 542, L. 1995.)

History: En. Sec. 5, Ch. 712, L. 1991; amd. Sec. 4, Ch. 568, L. 1993.

75-10-101. Purpose. The purpose of this part is to encourage the good management of solid waste and the conservation of natural resources through the promotion or development of systems to collect, separate, reclaim, recycle, and dispose of solid waste for energy production purposes where economically feasible and to provide a coordinated state solid waste and resource recovery plan.

History: En. 69-4012 by Sec. 2, Ch. 575, L. 1977; R.C.M. 1947, 69-4012(part).

75-10-105. Powers of department. The department may:

(1) accept loans and grants from the federal government and other sources to carry out the provisions of this part;

(2) make loans to a local government for the planning, design, and implementation of a solid waste management system;

(3) make grants for a local government for planning or implementation of a solid waste management system; and

(4) collect the solid waste management fee provided for in 75-10-118.

History: En. 69-4014 by Sec. 4, Ch. 575, L. 1977; R.C.M. 1947, 69-4014(2); amd. Sec. 2, Ch. 482, L. 1981; amd. Sec. 11, Ch. 696, L. 1989; amd. Sec. 3, Ch. 398, L. 1991; amd. Sec. 2, Ch. 145, L. 1993.

TRANSPORTATION ALTERNATIVES

15-6-201(1)(j). Exempt categories. (1) The following categories of property are exempt from taxation:

(j) a bicycle, as defined in 61-1-123, used by the owner for personal transportation purposes;

60-3-303. Footpaths and bicycle trails to be established -- funding. (1) The transportation commission or a county or city, with funds received from the state transportation commission state special revenue fund, may construct footpaths and bicycle trails. Footpaths and bicycle trails may be established and extended to the nearest city or town or termination point of the highway or road wherever a highway, road, or street is being constructed, reconstructed, or relocated. In addition, footpaths and bicycle trails may be established along all streets under state jurisdiction. Funds received from the state special revenue fund may also be expended to construct footpaths and bicycle trails along other highways, roads, and streets and in parks and recreation areas if the construction enhances traffic safety and convenience. Footpaths and bicycle trails may be constructed along all sections of the national defense interstate highway system.

(2) Footpaths and trails may not be established under subsection (1) of this section:

(a) if the cost of establishing the paths and trails is excessively disproportionate to the need or probable use; or

(b) if sparsity of population, other available ways, or other factors indicate an absence of any need for the paths and trails.

(3) The state transportation commission shall let to contract in any period of 5 consecutive fiscal years not less than an average of $200,000 per year for footpaths and bicycle trails. The department shall establish accounting procedures to document compliance with this subsection.

History: En. 32-2626 by Sec. 3, Ch. 544, L. 1975; R.C.M. 1947, 32-2626; amd. Sec. 18, Ch. 23, L. 1979; amd. Sec. 1, Ch. 277, L. 1983; amd. Sec. 1, Ch. 60, L. 1989; amd. Sec. 6, Ch. 75, L. 1995.

UTILITY PROGRAMS

15-32-107. Loans by utilities and financial institutions -- tax credit for interest differential for loans made prior to July 1, 1995. (1) Except as provided in subsection (4), a public utility or a financial institution that lent money or made qualifying installations under this section as it read prior to July 1, 1995, may compute the difference between interest it actually receives on the transactions and the interest that would have been received at the prevailing average interest rate for home improvement loans, as prescribed in rules made by the public service commission. The utility may apply the difference so computed as a credit against its tax liability for the electrical energy producer's license tax under 15-51-101 or for the corporation license tax under chapter 31, part 1. The public service commission shall regulate rates in such a manner that a utility making loans under this section may not make a profit as the result of this section. The financial institution may apply the difference so computed as a credit against its tax liability for the corporation license tax under chapter 31, part 1.

(2) A utility may not claim a tax credit under this section exceeding $750,000 in any tax year. A financial institution may not claim a tax credit under this section exceeding $2,000 in any tax year.

(3) The public service commission may make rules to implement this section as it applies to public utilities only.

(4) A public utility whose purchases of or investments in conservation are placed in the rate base as provided in Title 69, chapter 3, part 7, may not receive a tax credit under subsection (1).

History: En. 84-7405 by Sec. 5, Ch. 548, L. 1975; R.C.M. 1947, 84-7405; amd. Sec. 1, Ch. 666, L. 1979; amd. Sec. 1, Ch. 266, L. 1981; amd. Sec. 7, Ch. 610, L. 1983; amd. Sec. 1, Ch. 331, L. 1987; amd. Sec. 1, Ch. 535, L. 1993.

69-3-305(5)(b) A public utility providing electricity or natural gas may offer grants and subsidized loans to install energy conservation and nonfossil forms of energy generation systems in dwellings.

(c) The commission may define the appropriate scope of promotions, rebates, market trials, and grants and subsidized loans, either by rule or in response to complaints. The commission may determine whether a particular sales activity or grant or subsidized loan program under this subsection is unfairly discriminatory or is not cost-effective. Costs and expenses incurred or revenue foregone with respect to sales activities and grant and subsidized loan programs that the commission determines are unfairly discriminatory or not cost-effective are the responsibility of the provider's shareholders in rates set by the commission.

History: En. Sec. 12, Ch. 52, L. 1913; re-en. Sec. 3892, R.C.M. 1921; re-en. Sec. 3892, R.C.M. 1935; R.C.M. 1947, 70-114; amd. Sec. 1, Ch. 327, L. 1983; amd. Sec. 6, Ch. 210, L. 1991; amd. Sec. 1, Ch. 207, L. 1993; amd. Sec. 2, Ch. 535, L. 1993; amd. Sec. 29, Ch. 349, L. 1997.

69-3-703. Utility investment in or purchase of conservation -- approval by commission. (1) A utility may:

(a) purchase conservation from a person or private firm; or

(b) directly engage in conservation investments.

(2) The conservation purchases or investments provided for in subsection (1) are subject to approval by the commission.

(3) Cost-effective conservation measures approved by the commission may, at the customer's discretion, be installed by either:

(a) a person or a private firm;

(b) the customer himself; or

(c) the utility.

History: En. Sec. 2, Ch. 610, L. 1983.

69-3-712. Commission to include conservation in rate base -- rate of return. (1) In order to encourage the purchase of or investment in conservation by a utility, the commission shall include conservation purchases or investments eligible under 69-3-702 and in compliance with criteria adopted under 69-3-711 in a utility's rate base.

(2) In establishing such rate of return the commission may allow an increment of up to 2% added to the rate of return on common equity permitted on the utility's other investments.

(3) The commission shall allow the rate of return increment provided for in subsection (2) for a period not to exceed 30 years after the conservation is first placed in the rate base.

(4) The commission shall prescribe amortization periods for conservation that is included in a utility's rate base.

History: En. Sec. 4, Ch. 610, L. 1983.

69-8-402. Universal system benefits programs. (1) Universal system benefits programs are established for the state of Montana to ensure continued funding of and new expenditures for energy conservation, renewable resource projects and applications, and low-income energy assistance during the transition period and into the future.

(2) Beginning January 1, 1999, 2.4% of each utility's annual retail sales revenue in Montana for the calendar year ending December 31, 1995, is established as the annual funding level for universal system benefits programs. Unless modified as provided in subsection (7), this funding level remains in effect until July 1, 2003. (a) The recovery of all universal system benefits programs costs imposed pursuant to this section is authorized through the imposition of a universal system benefits charge assessed at the meter for each local utility system customer as provided in this section.

(b) Utilities must receive credit toward annual funding requirements for a utility's internal programs or activities that qualify as universal system benefits programs, including those portions of expenditures for the purchase of power that are for the acquisition or support of renewable energy, conservation-related activities, or low-income energy assistance, and for customers' programs or activities as provided in subsection (7).

(c) A utility at which the sale of power for final end-use occurs is the utility that receives credit for the universal system benefits program expenditure. For a utility to receive credit for low-income related expenditures, the activity must have taken place in Montana.

(d) For a utility to receive credit for low-income related expenditures, the activity must have taken place in Montana.

(e) If a utility's or a customer's credit for internal activities does not satisfy the annual funding provisions of subsection (2), then the utility shall make a payment to the universal system benefits fund for any difference.

(3) Cooperative utilities may collectively pool their statewide credits to satisfy their annual funding requirements for universal system benefits programs and low-income energy assistance.

(4) A utility's transition plan must describe how the utility proposes to provide for universal system benefits programs, including the methodologies, such as cost-effectiveness and need determination, used to measure the utility's level of contribution to each program.

(5) A utility's minimum annual funding requirement for low-income energy and weatherization assistance is established at 17% of the utility's annual universal system benefits funding level and is inclusive within the overall universal system benefits funding level.

(a) A utility must receive credit toward the utility's low-income energy assistance annual funding requirement for the utility's internal low-income energy assistance programs or activities.

(b) If a utility's credit for internal activities does not satisfy its annual funding requirement, then the utility shall make a payment for any difference to the universal energy assistance fund.

(6) An individual customer may not bear a disproportionate share of the local utility's funding requirements, and a sliding scale must be implemented to provide a more equitable distribution of program costs.

(7) (a) A customer with loads greater than 1,000 kilowatts shall:

(i) pay a universal system benefits program charge equal to the lesser of:

(A) $500,000 less the customer credits provided for in this subsection (7); or

the product of 0.9 mills per kilowatt hour multiplied by the customer's kilowatt hour purchases, less customer credits provided for in this subsection (7);

(B) the product of 0.9 mills per kilowatt hour multiplied by the customer's kilowatt hour purchases, less customer credits provided for in this subsection (7);

(ii) receive credit toward that customer's annual universal system benefits charge for internal expenditures and activities that qualify as a universal system benefits program expenditure and these internal expenditures must include but not be limited to:

(A) expenditures that result in a reduction in the consumption of electrical energy in the customer's facility; and

(B) those portions of expenditures for the purchase of power at retail or wholesale that are for the acquisition or support of renewable energy or conservation-related activities.

(b) Customers making these expenditures must receive a credit against the customer's annual universal system benefits charge, except that any of those amounts expended in a calendar year that exceed that customer's universal system benefits charge for the calendar year must be used as a credit against those charges in future years until the total amount of those expenditures has been credited against that customer's universal system benefits charges.

History: En. Sec. 22, Ch. 505, L. 1997.

Senate Bill No. 409, 1999 Legislature. The 1999 Legislature enacted Senate Bill No. 409 "An Act Authorizing Net Metering for Certain Energy Systems," which amended 69-8-103 and added new sections 69-8-601 through 604.

69-8-103. (17) "Net metering system" means a facility for the production of electric energy that:

(a) uses as its fuel solar, wind, or hydropower;

(b) has a generating capacity of not more than 50 kilowatts;

(c) is located on the customer-generator's premises

(d) operates in parallel with the distribution services provider's distribution facilities; and

(e) is intended primarily to offset part or all of the customer-generator's requirements for electricity.

69-8-602 (new). Distribution services provider net metering requirements. A distribution services provider shall:

(1) allow net metering systems to be interconnected using a standard kilowatt-hour meter capable of registering the flow of electricity in two directions, unless the commission determines, after appropriate notice and opportunity to comment:

(a) that the use of additional metering equipment to monitor the flow of electricity in each direction is necessary and appropriate for the interconnection of net metering systems, after taking into account the benefits and costs of purchasing and installing additional metering equipment; and

(b) how the costs of net metering are to be allocated between the customer-generator and the distribution services provider; and

(2) charge the customer-generator a minimum monthly fee that is the same as other customers of the electric utility in the same rate class. The commission shall determine, after appropriate notice and opportunity for comment if:

(a) the distribution services provider will incur direct costs associated with interconnecting or administering systems; and

(b) public policy is best served by imposing these costs on the customer-generator, rather than allocating these costs among the distribution services provider's entire customer base.

69-8-603 (new). Net energy measurement calculation. Consistent with the other provisions of [sections 1 and 3 through 5], the net energy measurement must be calculated in the following manner:

(1) The distribution services provider shall measure the net electricity produced or consumed during the billing period, in accordance with normal metering practices.

(2) If the electricity supplied by the electricity supplier exceeds the electricity generated by the customer-generator and fed back to the electricity supplier during the billing period, the customer-generator must be billed for the net electricity supplied by the electricity supplier, in accordance with normal metering practices.

(3) If electricity generated by the customer-generator exceeds the electricity supplied by the electricity supplier, the customer-generator must be:

(a) billed for the appropriate customer charges for that billing period, in accordance with [section 3]; and

(b) credited for the excess kilowatt hours generated during the billing period, with this kilowatt-hour credit appearing on the bill for the following period.

(4) At the beginning of each calendar year, any remaining unused kilowatt-hour credit accumulated during the previous year must be granted to the electricity supplier, without any compensation to the customer-generator.

Effective date. [This act] is effective July 1, 1999.

WIND ENERGY

(See Solar and Wind Energy)